SCIENTIFIC AMERICAN SUPPLEMENT No. 826



Scientific American Supplement Vol. XXXII. No. 826
Scientific American, established 1845.

NEW YORK, OCTOBER 31, 1891.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

## CHIMNEY FOR THE NARRAGANSETT ELECTRIC LIGHTING COMPANY, PROVIDENCE, R. I.

By John T. Henthorn, M. Am. Soc. C. E.

The chimney for the Narragansett Electric Lighting Company, of Providence, R. I., was designed by the writer's firm (Remington & Henthorn) and built under their supervision. It forms a part of a large central station which was in process of construction at the same time under the supervision of the same designers.

The location of the center of the chimney is 101 ft. west of the harbor line of the Providence River, and the foundation, which was begun in August, 1888, formed part of a general contract for other portions of the station. This foundation consists of piling and concrete, and to arrange for it, a space 44 ft. square was first excavated 5 ft. 6 in. below zero line or high water, and the sides protected by driving 3 in. spruce sheet piling 16 ft. long. Over this excavation the pile driver, having a ram weighing 2,200 pounds, was rolled. Spruce piles, to the number of 231, 50 ft. long, and spaced 30 in. center to center, were driven as far as possible without breaking. These piles were cut off uniformly at 5 ft. below the high water line, the earth around their heads thus being 6 in. below their tops. The intervening space between the sheet piling was filled in with concrete composed of one part of Norton's hydraulic cement, two parts sand, and three parts coarse gravel and broken stone. This mass was carried up to the 1 ft. 3 in. level, and consequently formed a foundation 6 ft. 9 in. thick, with the head of each pile projecting 6 in. therein. This was then covered with earth and allowed to season during the winter.

On May 31, 1889, work was resumed by laying the first brick of the chimney. This was carried up in the form of a square of 36 ft. to a height of 3 ft. 2 in., and from that level the base of the chimney proper, which was 28 ft. 6 in. square, was started.

The center of the chimney was fixed by building into the brick work a cast iron plate, upon which was a well defined center mark. From this center mark all measurements and plumbing were established while the chimney was being built. As each 20 ft. in height was built, the center of its axis was re-established, and if any deviation from the plumb was found, it was corrected before the next 20 ft. level was reached.

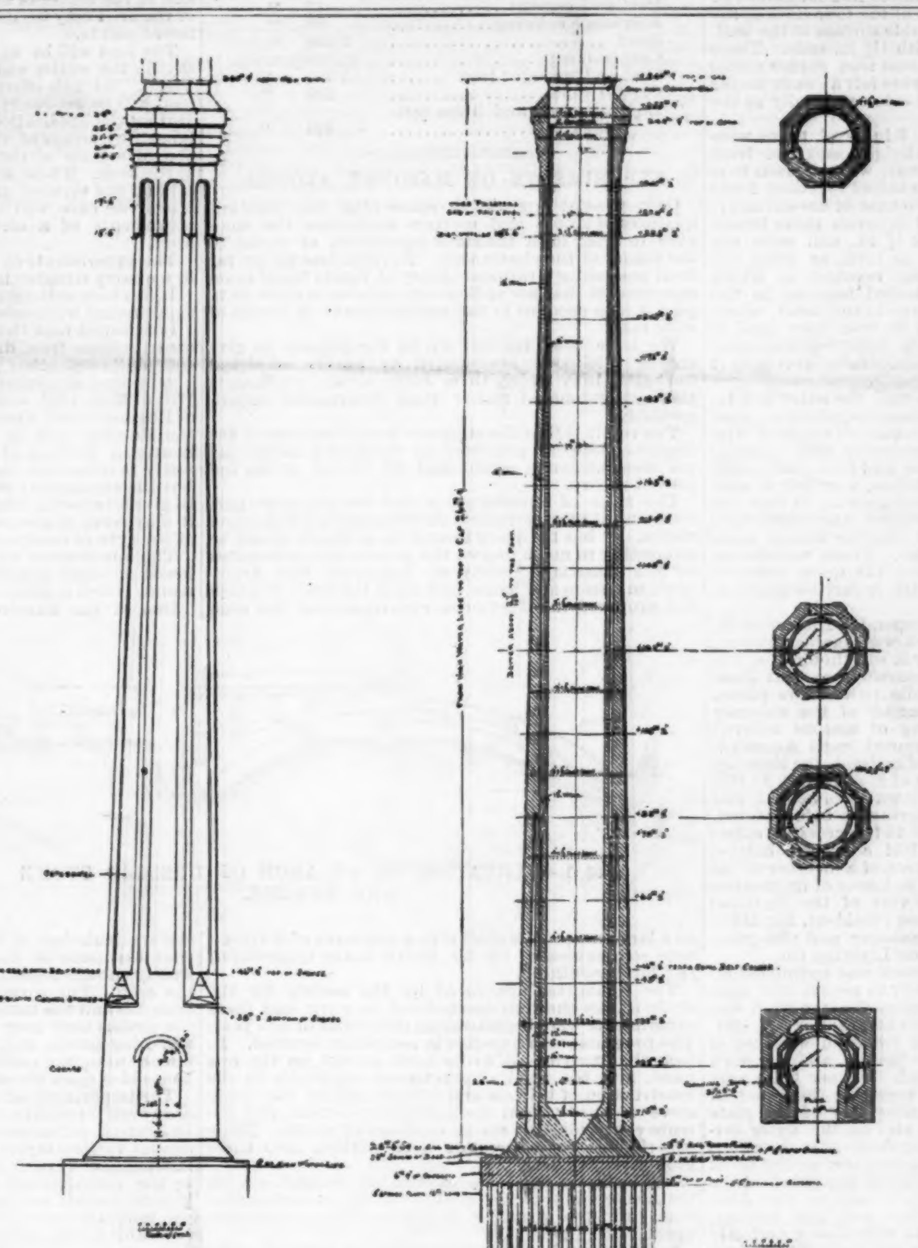
The base of the chimney, which, as before stated, is 28 ft. 6 in. square, consists of three walls: an outer wall 28 in. thick; an intermediate wall, octagonal in form, 12 in. thick; and a core wall circular in section, 16 in. thick. The outer and intermediate walls are joined by pilasters 12 in. thick.

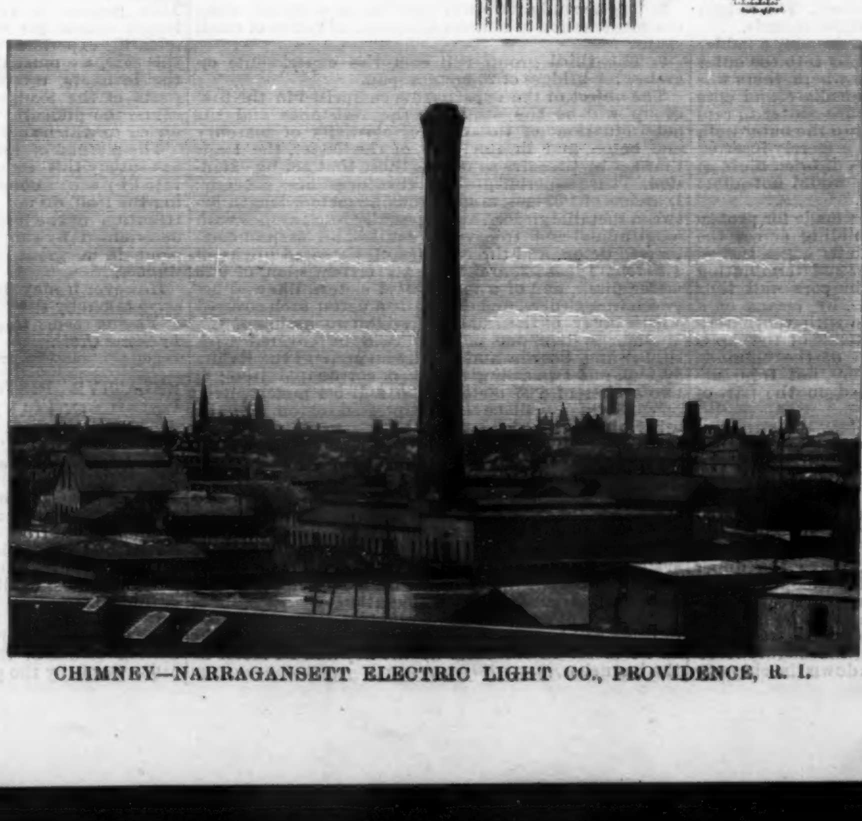
In commencing the base of what might be termed the core wall, each course of brick was set back 2½ in. from the previous course until inside diameter, 14 ft., was reached, when the wall was carried plumb 16 in. in thickness up to the 78 ft. 2 in. level, where it was reduced to 12 in., and run up to 193 ft. 3 in., when it was again reduced in thickness to 8 in., and thus carried to 249 ft. 9 in. This wall complete was laid in lime mortar, which had been slaked from three to six months before using. The outer wall, of rectangular cross section, was carried up to the 38 ft. 2 in. level, where at each of the four corners cut granite blocks were placed, to change from a square to an octagonal cross section. This granite work is made up of three pieces in the lower course of 2 ft. 8 in. in thickness, and two courses with one stone each, also 2 ft. 8 in. in thickness. On the angular face of these stones was cut a triangular section or projection to relieve the monotony of a plain surface, and when in place they fulfilled their mission to perfection. Level with the top of this granite work and in the center of the panel of the octagonal side is laid a terra cotta brick belt course, which thus forms the commencement of the 24 inch pilasters at each of the octagonal corners, and leaves an intervening panel 4 in. deep of varying width, as the chimney is reduced in size by the batter. These pilasters are carried up to the 223 ft. 2 in. level, at which point the first projection for the head is made, and from that point carried still further, on the same batter, up to the crown of the arches, which are then turned between the panels.

The outside wall, together with the intermediate wall and their pilasters up to the 38 ft. 2 in. level, were laid up with cement mortar, one part cement and two parts of sharp sand, excepting the outside course of the outer wall, which was laid in soapstone finish mortar, of a dark red color. From this level (38 ft. 2 in.) up to the commencement of the head, 223 ft. 2 in., the outer wall was laid up with mortar consisting of two parts lime and one of cement. For laying up the head from the 223 ft. 2 in. level up to the point to receive the cast iron cap, one part of lime and one of cement were used, and for backing up underneath the cap after it had been thoroughly screwed together, three sand and one Portland cement was used. Special brick was used for the outside course at each of the corners of the octagon, which were moulded to shape in order to avoid cutting and at the same time secure a better outside finish. The bond throughout the entire structure consisted of full headers for every six courses of brick work. This method of construction was carried on up to the 66 ft. 2 in. level, when work was suspended November 29, for the season of 1889, and the top of the structure covered with matched boarding and tarred paper for the winter.

The chimney was built entirely from the inside platform, the masons working overhanded, and thus no staging was necessary on the outside.

Up to the level of the granite work all the stock used was carried up a ladder placed on the outside. But at this point there was constructed inside the 14 ft. chimney flue an elevator, fitted with safety clutches and capable of carrying 1,000 pounds, although not more than 450 pounds was al-





CHIMNEY—NARRAGANSETT ELECTRIC LIGHT CO., PROVIDENCE, R. I.

* From the Transactions of the American Society of Civil Engineers.

lowed to be placed upon it at any one time; and thereafter everything used in the process of construction was sent up on the elevator, to hoist which a nineteen-strand steel cable was used. The temporary framework inside the flue consisted of four 6 × 8 in. timbers, laid across each other at right angles, in pairs, and built into the wall at intervals of every 5 ft. Through the opening at the center, the elevator passed. Over these timbers was laid a platform of 2 in. plank, upon which the masons performed their work. To these 6 × 8 in. horizontal timbers, at opposite corners, were bolted the vertical guides for the elevator and the upright framing by which it was hoisted; these were spliced out at the top each alternate staging.

The opening for smoke flues is 10 ft. wide and 18 ft. high, with a 28 in. arch of 5 ft. radius. The lower part of the opening is on the 14 ft. 2 in. level. Directly below and above the opening on the 13 ft. 2 in. and 33 ft. 2 in. levels were placed in each of the four sides of the chimney, and 8 in. from the outside surface of the wall, two $1\frac{1}{4}$ in. diameter tie rods, with $1\frac{1}{2}$ in. ends. These were all connected together by cast iron corner plates 12 × 14 in. square. Openings were left at each corner so that the nuts could be examined occasionally as the work dried out.

From and including the 53 ft. 2 in. level, there were laid edgewise at each 20 ft. in height, and 8 in. from the outside surface of the chimney, wrought iron bars of 4 in. × $\frac{1}{2}$ in., with their ends bolted together, forming an octagon corresponding to that of the chimney. At the 133 ft. 2 in. and 153 ft. 2 in. levels these braces were reduced in size to 3 in. × $\frac{1}{2}$ in., and were not again used until the 223 ft. 2 in. level, or when the commencement of the head was reached, at which point bars 3 in. × $\frac{3}{8}$ in. were bolted together in the wall. Their next application was in the head, where two braces made of 4 in. × $\frac{1}{2}$ in. iron were used to assist in binding the heavy brick work together during construction, which had considerable overhang (2 ft. 9 in. on each side).

With reference to the outside wall, the outer and intermediate walls, with their connected pilasters, were built as one structure and terminated on the 83 ft. 2 in. level, where by the batter of the outer wall it joined the intermediate and became one wall from that point. At this level two holes, 5 × 8 inches, were left in each of the eight sides of the intermediate wall, so that the intervening space between the outer and inner walls might be ventilated, if by any possible chance gases should find access to this space. These ventilating holes are in communication with the space between the outer wall and the core, which is carried nearly to the top.

As before stated, work was suspended November 29, 1889, and on April 22, 1890, work was again resumed, but on account of bad weather it was thought well to hurry the construction along somewhat, so that June 28 four arc lights of 2,000 candle power were placed upon the top of the elevator staging of the chimney for lighting at night, and a gang of masons relieved the day gang. This was continued until August 6, 1890, when the night gang was dismissed, the chimney having then reached the height of 223 ft. 2 in. At this point the head of the structure was commenced, and gradually built up in cement mortar, as before stated, and measured when completed 24 ft. across its sides; and on the 10th day of March, 1891, a flag was hoisted on its top by the eight-year-old son of a member of the firm of the designing engineers in honor of its completion and in celebration of the visit of the National Electric Light Association, whose president, Mr. Marsden J. Perry, is also general manager and vice-president of the Narragansett Electric Lighting Co.

On October 4, 1890, all brick work was completed up to the 253 ft. 9 in. level, and ready to receive the cast-iron cap, but on account of delays the iron work was not received to place in position until January 26, 1891. On February 11 the first of the twenty-five pieces of the cast-iron cap was hoisted to the top, and the work of bolting it together commenced. Copper bolts were used entirely for securing it together; these passed through flanges cast on the under side of the plate forming the cap. There were also on the outer surface upright flanges, one turning down over the other, and thus preventing water from penetrating the brick through the joints of the cap. All of the joints of the cap where there was a possibility of leakage were carefully filled in with sal ammoniac and iron borings, thoroughly rammed or calked in, and thus a perfectly tight and secure connection was obtained. The weight of the cap alone when in place was 22,000 pounds.

In order to facilitate ascending the chimney a ladder made of $1\frac{1}{4}$ round iron was built solidly into the outer wall at a point in its circumference where there was the greatest space between the intermediate and core walls; these bars were spaced 16 inches center to center, and as before stated were built into the outer wall, while in the core wall their ends were merely inserted into a cavity, 2 in. wide and a course of brick high, so that any expansion of the inner core would not affect the solidity of the ladder.

Ascending this ladder, provision is made for protection from the gases at the top by building across the corner a cast-iron vertical plate, with its edges turned into the brickwork 8 in. and its lower end terminating at a point 3 ft. below the top of the core wall, thus forming a chamber; and from this, by means of a hatchway in the cap, also provided with ventilating openings in its side, access to the outside of the cap is readily had. Since the completion of the chimney this ladder has been used several times, not from necessity, but for the novelty of the deed on the part of workmen.

An attempt has been made to protect the structure from lightning by encircling the cast-iron cap with a copper ribbon 1 × $\frac{1}{16}$ in. thick, to which are connected by a riveted and soldered joint eight brass upright sockets, one in the center of each panel of the cap. To these brass socket castings are secured by soldered joint $1\frac{1}{4}$ in. seamless drawn copper tubing which extends upward above the top of the cap and conforms to its shape. After projecting 5 ft. above the upper portion of the cap the tubes are each surmounted by a brass casting 28 in. long, tapering in cross section and having at its extremity a platinum point $1\frac{3}{8}$ in. long. The encircling ribbon around the cap is connected with the ground ribbon by a casting thoroughly riveted and soldered thereto. As it runs down the chimney this ground ribbon is secured in position by brass clamps with bolts which were built into the brickwork as it progressed. The lower end of the ribbon, which is 1 × $\frac{1}{16}$ in. copper, rolled in one piece 285 ft. long, terminates in a copper plate 30 in. wide by 60 in. long and $\frac{1}{16}$ in. thick, and is buried 4 ft. below the natural level of the water in the soil of the premises. This plate is buried in a load of powdered coke, 18 in. being placed above and 18 in. in thickness below the plate, and the whole filled up with gravel.

After completion, the outside of the chimney was thoroughly oiled, in order to bring the brickwork to one uniform color.

The amount of material used in the course of construction above the concrete foundation is as follows:

| | | |
|---|---|---|
| Brick | 1,332,921 | |
| Lime | 695 | casks. |
| F. O. N. cement | 1,025 | " |
| Portland cement | 17 | " |
| Soapstone coloring | 99 | " |
| Sand | 3,858 | " |
| Cast-iron cap | 22,000 | pounds. |
| Cast and wrought iron | 7,215 | " |
| Copper bolts | 250 | " |
| Lightning rod and brass castings | 326 | " |

## EXPERIMENTS ON MASONRY ARCHES.

OUR present knowledge concerning the resistant qualities of stones and mortars authorizes the engineer to bring back the static calculation of vaults to the theory of the elastic arch. Nevertheless we are far from possessing a rational theory of vaults based upon experiments that are sufficiently decisive to allow us to take it into account in the establishment of arches of wide span.

We have been content up to the present to give arches thicknesses calculated by purely empirical formulas, into which there enter certain coefficients that are estimated rather than determined experimentally.

The result is that the engineer is still ignorant of the degree of security presented by works of a certain importance, although established by the aid of the improved theory.

This state of uncertainty is due for the most part to the want of experiments on breakage upon finished vaults. It has therefore seemed to us that it would be interesting to make known the programme elaborated by the Austrian Society of Engineers and Architects, in session at Vienna, and upon the basis of which it is proposed to effect some experiments of this kind on a large scale. We shall give a summary of it from a note communicated by Mr. Melan to the *Centralblatt fur Bauverwaltung.*

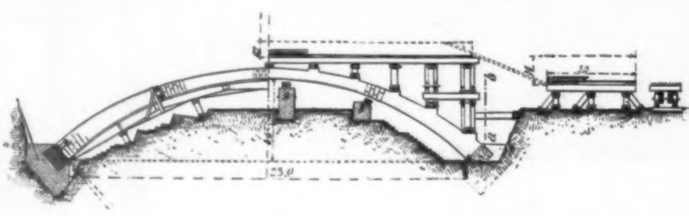


FIG. 1.—ELEVATION OF AN ARCH OF DRESSED STONE AND RUBBLE.

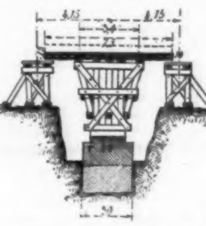


FIG. 2.—SECTION THROUGH *a b*.

The committee appointed by the society for the study of this question has finished its work, and these experiments were begun during the course of last year. The programme in question is somewhat detailed. In fact, the experiments to be made should, on the one hand, give the results immediately applicable in the construction of bridges and edifices, and on the other serve to throw light upon certain questions still obscure concerning the elastic qualities of vaults. These experiments have therefore been divided into three groups:

1. The first group includes scientific researches upon the elastic and resistant qualities of the materials that enter into the structure of the vaults experimented upon.

2. The second group will comprise experiments upon the construction of ceilings composed of vaults of small spans.

3. The third group will comprise experiments on arches for bridges of 23 meters span.

The object of the experiments comprised in the first group will be the study of the resistance and the determination of the data of elasticity of masonry and beton, and in the case of the latter, the loads that act by pressure as well as those that act by extension. These experiments on arches for edifices concern: 1, arches of 1·35 meters span and of 2 meters length between metallic girders, and especially brick arches with longitudinal and transverse courses, an arch of compressed beton, and three arches of patented bricks of different types; 2, arches of 2·7 meters span, of 0·25 meter pitch, and of a length of 2 meters, likewise between iron girders, and especially a beton arch covered with a layer of the same material, two arches of the Monnier system, one of which will be covered with rubber and boards, and finally an arch of the Rabitz system, and two ceiling arches of corrugated iron; 3, two arches of 4·05 meters span and 0·4 meter pitch, one of which will be of compressed beton and the other of the Monnier system, both covered with rubber and wood.

The experiments relating to arches for bridges will certainly present the greatest interest. These arches will have a span of 23 meters and will be surbased to $\frac{1}{5}$, and will have a width of 2 meters. Five of these arches will be constructed of rubber, dressed stone, brick, and beton compressed according to the Monnier system. Finally, it is proposed to make comparative experiments upon an iron plate bridge having the same span as the arches under consideration.

The arch of dressed stones and the one constructed of brick will be established as shown in Fig. 1 and will be 0·6 meter in thickness at the key and 1·1 meter at the haunches.

The brick arch will be 0·6 meter in thickness at the key, 1·2 meter at the haunches, and will be strengthened with four successive courses. The determination of the dimensions of the arches of beton and of those of the Monnier type will be made by the contractors who have offered to take part in the experiments. Care will be taken to give those arches the necessary thickness for railway bridges, and the load per running meter will be supposed equal to 3 tons. The same hypotheses will be available for the iron plate arch.

The construction of these works must be done in such a way that it shall be possible to obtain as exact a comparison as possible between the results of various experiments. Consequently, for all the bridge arches the same Portland cement will be used, and for all the masonry arches there will be employed a mortar made by an identical mixture. The mason work of the arches will be done simultaneously at the haunches and at the center of each half span, so that the closing of the arch may be done simultaneously at three different points.

The load will be applied on a single side, that is to say on the entire width of a half span, as shown in Fig. 1. To this effect, iron rails will be used. This load will be gradually increased until the arch breaks. During the application of the load, there will be determined, by means of simple measuring arrangements, the distortions at the haunches and at several points of the arch. These arrangements will permit of determining the vertical and the horizontal displacements. Moreover, care will be taken to note the torsional movements of a certain number of sections of the arch.

The experiments on arches of wide span will be made in a quarry situated in the neighborhood of Vienna.

It has been estimated that the total expense of these experiments will reach 38,000 francs in round numbers.

It is hoped that this sum will be entirely covered by contributions from different administrations, railway companies and other participants.

A preliminary experiment was made on the 16th and 17th of May, 1890, with the concurrence of the Society of Engineers and Architects of Vienna upon an arch of the Monnier type of 10 meters span erected by the Southern Railway of Austria. The object of it was solely to determine the strength of arches of this type, but the experiment was not effected in such a way as to give interesting scientific results. Still the results of it may serve to give some information as to the value of the type of construction in question.

The publication of this note by Mr. Melan was followed in same journal by a remark by Mr. Zimmermann, which appears to us worthy of reproduction.

One of the numerous difficulties met with in the static calculation of loaded arches is due to the fact that the parts of the load are not, as a general rule, widely enough separated, and do not act directly upon the arch. The springings of the arch, as well as the tympans and the materials used for filling, and likewise the girders that may eventually rest thereon, exert a stiffening action, and, consequently, have a notable influence upon the point of application of the load, and hence also upon the strength of the arch.

The importance of such influence cannot be estimated even approximately. In most cases, we have to be content in the calculation to divide the load into several vertical layers that we suppose afterward to be independent of each other. This process is legitimate by the consideration that the interdependence which in reality exists between the different layers, and which we take no account of, can give only a hypothesis favorable for the calculation of the strength of the arch. This process, however, does not appear to be any longer admissible when it is a question of making scientific experiments on the strength of arches. In this case, we must determine the influence exerted by the intimate interdependence between the various parts of the load, or else, if such determination becomes too difficult, we must adopt a kind of loading owing to which such influence is suppressed.

The method of loading shown in Figs. 1 and 2 does not satisfy this condition, since the platform constituted by continuous girders, as well as the rails forming the load, do not possess much stiffness. The distribution of the load in this case would no longer be determined by simple statics, and, besides, would depend in a great measure upon fortuitous circumstances.

However it may be with this observation, the initiative taken by the Society of Architects and Engineers of Vienna seems to us to be worthy of great praise.—*Le Genie Civil.*

## RELATIVE PISTON SPEEDS OF OSCILLATING AND OTHER ENGINES.

By Prof. C. W. MACCORD, Sc.D.

IF the crank of a steam engine be supposed to rotate with uniform velocity, the speed of the piston will be variable; and it is quite apparent that the law of variation will depend upon the manner in which motion is transmitted from the piston to the crank-pin. The object of this article is to show the effect of different connections upon this law of variation; and the comparison is most readily as well as most clearly made by graphic methods.

In Fig. 1, let the horizontal line S T, divided into ten equal parts as shown, represent the time occupied by one stroke of the engine from right to left, or in other words by the passage of the crank-pin through

the semi-circumference S A T, in Fig. 2; then the points of division, 1, 2, 3, etc., represent instants separated by equal intervals of time. If now at these points we set up, on any convenient scale, vertical ordinates proportional to the speed of the piston at the corresponding instants, the law of variation is exhibited to the eye at a glance by the curve thus determined.

Four such curves, marked X, Y, W, Z, are given in Fig. 1, showing the piston speeds in the four different arrangements illustrated by the small diagrams at the left, which are lettered to correspond.

The first of these skeleton movements, X, represents the "slotted cross-head connection," which is equivalent to a connecting rod of infinite length; the second, Y, shows the crank and finite connecting rod of the ordinary direct-acting engine; the other two represent oscillating engines, the trunnion or center of oscillation being placed at the center of the length of the cylinder in the third diagram W, while in the fourth one, Z, it is placed at the end of the cylinder farthest from the crank-shaft.

The motion of the crank-pin is always perpendicular to the radius or center-line of the crank; and a moment's study of the slotted cross-head movement shows that the vertical component of this motion is simply one of sliding in the slot, so that the horizontal component determines the speed of the piston, which travels with a perfect harmonic motion, with a velocity always less than that of the crank-pin, except at the middle of its stroke, at which instant the crank is vertical, and the velocities of the pin and the piston are equal. Accordingly the velocity-curve X X in Fig. 1, which indeed is obviously the harmonic curve or sinusoid, is symmetrical about its central and maximum ordinate M, which represents also the actual linear velocity of the crank-pin.

The substitution of a finite connecting-rod, clearly, will distort this curve and destroy its symmetry, by reason of the angular vibration, and the distortion will be the greater, the shorter the rod; and in order to make the effect more pronounced, we have in the second small diagram made it of much less than the usual length.

In the corresponding velocity curve YY, Fig. 1, we notice, besides the distortion, the striking peculiarity that the piston attains a higher speed than before. There are two instants when the velocity of the piston in this arrangement will be exactly equal to that of the crank-pin, one when the crank is vertical, as AC in Fig. 2, and the other when the position A D of the crank is such that the prolongation of ED, the center line of the connecting rod, passes through the point A.

In the former case, the motions of the points A and B are parallel to each other, and not perpendicular to the line A B; and since the components A G, B G', along that line, must be equal, it follows that if we assign any velocity A F to the point A, the resultant velocity B F' of the point B must be the same.

The demonstration relating to the latter case is for the sake of perspicuity given with reference to the position C D', symmetrical with C D. Let the velocity of the crank-pin be represented by D' H perpendicular to C D'; resolve this into the components D' I in the direction E D', and D' J perpendicular to that line; the component E I' must be equal to D' I, and since E must travel in the direction E C, its resultant velocity is found by drawing through I' a perpendicular to E D', cutting E C in H'. Now H D' C being a right angle, we have angle H D' I = 90° (angle C D' A'); and A' C E being also a right angle, angle C E A' = 90° (angle C A' D'); but the angles C D' A', C A' D', are equal, consequently angle I D' H = angle I' E H; the right-angled triangles H D' I, H' E I', are therefore similar, and since the bases D' I, E I', are equal, the triangles themselves are equal, and E H' = D' I, as stated.

Since all the velocity curves are laid out on the same scale for the purpose of comparison, the second one Y Y will have the same ordinate M as the first one, at the middle point of the base line, and an equal one N, whose position is determined by dividing the distance between M and the zero point into segments which are to each other as the arc A D is to the arc D S.

The process of determining the velocity of the piston corresponding to any other position of the crank is precisely the same as that above explained, and is, of course, to be repeated for each position determined by subdividing the arc S A T precisely as the base line of Fig. 1 is divided.

Fig. 2 serves equally well to show how the curves for the oscillating engines are laid out: For instance, when the crank is at C D', let E be the center of oscillation, then E D' I is the line of the piston rod; and D' H being assumed as the velocity of the crank pin, the component D I is the required piston speed. It is hardly necessary to add that in all the diagrams the crank is of the same length and is supposed to move at the same rate.

Referring again to the curve Y Y, we perceive that the location of the ordinate M, corresponding to the instant when the crank is vertical, is invariable; while that of the equal ordinate N will by reference to Fig. 2 be readily seen to depend upon the relative lengths of the crank and connecting rod. As the crank pin goes from D toward A, the speed of the piston first increases and then decreases, reaching a maximum at some intermediate point, which again is dependent upon the proportion between A C and A B. Thus the average speed of the piston during the first quarter revolution of the crank is considerably greater than in the case of the infinite connecting rod; as indeed it should be, since in this time it has traversed the distance U B, Fig. 2, which is more than half of U V, the whole stroke. During the remaining quarter it will travel from B to V, less than half the stroke; and the diminution of its velocity is indicated by the rapid droop of the curve Y Y on the left.

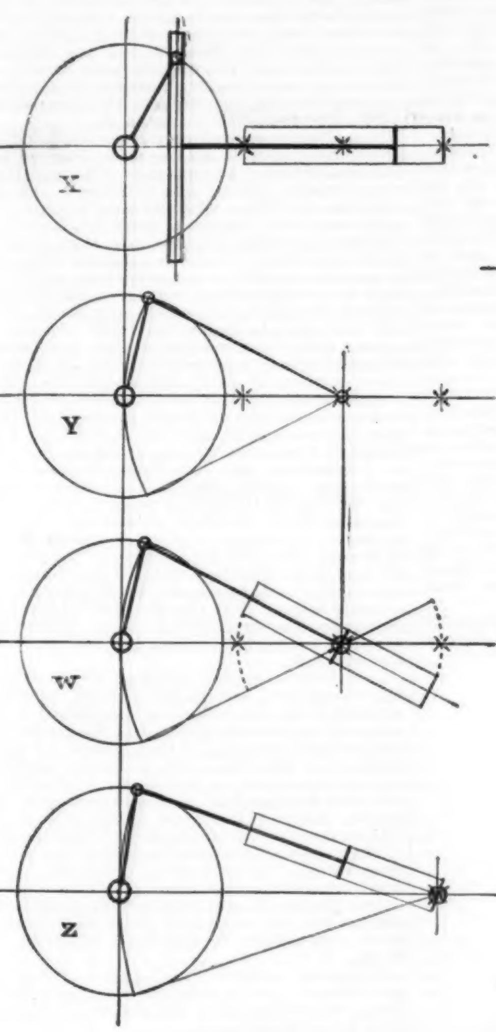
When the trunnion of an oscillating engine is placed at the center of the cylinder, as in the third skeleton diagram, the velocity curve takes the form W W in Fig. 1. In the first part of the stroke the speed of the piston increases more rapidly than in either of the preceding cases, the right-hand portion of this curve lying outside of all the others. The maximum ordinate O is equal to M, its location corresponding to the instant when the piston-rod is tangent to the path of the crank pin, both piston and pin then obviously moving at the same rate.

The nearer the center of oscillation is to the center of the crank shaft, the sooner will this tangency occur; and accordingly when, as in the fourth skeleton diagram, the trunnion is removed to the father end of the cylinder, we find the maximum ordinate located at P; thus the piston speed is diminished in the first part of the stroke and increased in the last part, as compared with the other oscillator, and the velocity curve Z Z is more nearly symmetrical than in either of the two preceding cases.

The proportions selected for these illustrations are such that in the second and third arrangements the piston reaches half stroke at the same time; the ordinate Q, which in Fig. 1 corresponds to that instant, is therefore common to the curves Y Y and W W. In the fourth arrangement this event occurs a little later, and the speed of the piston at that instant is represented by the ordinate R in the curve Z Z.

It is not pretended that in respect to minute accuracy the results of the graphic means of finding the ordinates, explained in connection with Fig. 2, are as reliable as those which might be reached by analytical calculations. But in point of expedition and facility of execution, the graphic method is incomparably superior, and if the constructions are made upon a reasonably large scale and with moderate care, the curves may be laid out with all the precision necessary for the purposes for which they are intended; indeed, when the unavoidable imperfections of workmanship in the building of the engines themselves are considered, it is probable that the actual variations in velocity do not differ more from those represented by a graphically constructed curve than they would from the computed ones.

Since the abscisses represent times, while the ordinates represent velocities, and since time × velocity = space, it follows that the area of each curve here shown represents the distance traversed by the piston in the time of a half revolution; therefore, since the stroke and the crank speed is the same in each arrangement, the areas of all four curves are equal. A good test of the accuracy of the determinations of velocity, then, in similar cases, is to make a careful computation of the areas; any serious discrepancy would indicate an error in the construction of one or other of the curves compared, but if they are found approximately equal, the curves may be accepted as practically accurate.



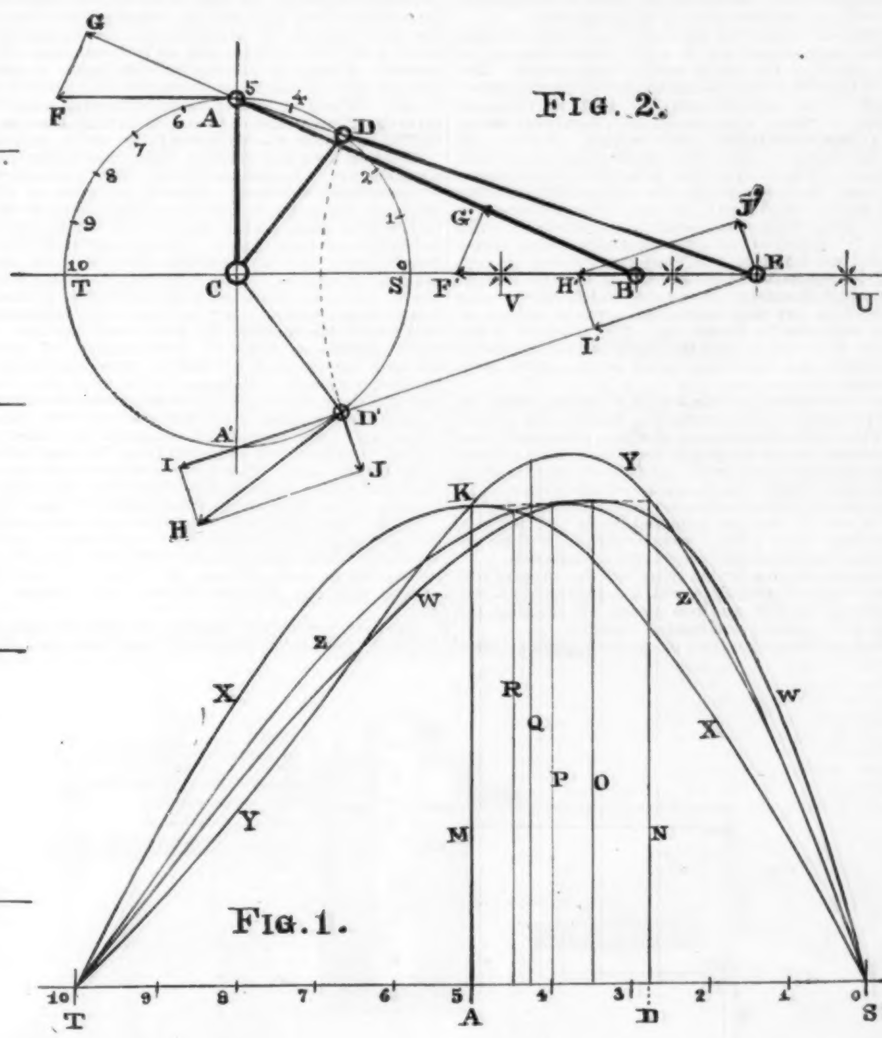



FIG. 2.

FIG. 1.

## EDISON'S ELECTRIC FURNACE.

THIS device by Thomas A. Edison is described in his recent patent as follows:

The object I have in view is to generate electricity directly from carbon, coal, or other carbonaceous material without the loss caused by the indirect method heretofore employed of converting the same into a motive power, from which electricity is produced by mechanical motion. This I accomplish by employing carbon or carbonaceous material for the generating or soluble electrode of a generating cell and in using therewith as an active agent oxides, salts, or compounds of elements, by the decomposition of which the carbon or carbonaceous material will be acted upon at high temperatures. The cell is constructed and adapted for the application of heat externally thereto, and the conducting or negative electrode of the cell is made of a substance which in the presence of carbon at high temperatures is not attacked to any great extent by the active agent employed.

The carbon electrode may be constructed in the

form of a solid cylinder of any desired size. It may be made of powdered bituminous coal, which is mixed with a little tar and pressed into a cylindrical iron retort by means of a follower and screw. The coal is then coked, the follower being forced upon it by the screw as the volatile portions pass off. The result of coking the bituminous coal under pressure is a compact solid cylinder of carbon of low electrical resistance. The carbon cylinder can also be of charcoal, formed by carbonizing wood in a close retort or vessel at a high temperature, which has the effect of making an exceedingly compact charcoal of low electrical resistance. The inclosing vessel is a pot, preferably of metal, which forms, preferably, of itself the inert or conducting negative electrode of the cell. Iron is a good material for the purpose. The pot has an open top closed by an insulating cover, which may be of fire clay, and through which the carbon cylinder passes, the carbon cylinder being supported by said cover or by a block in the bottom of the pot, which block is made of fire clay or of an insulating material not attacked by the particular active agent or compound used. The pot is placed in a suitable furnace for giving the requisite heat and it is connected with one circuit conductor, while the carbon cylinder is connected with the other. For this purpose the end of the carbon cylinder may be first electroplated and the conductor then soldered thereto, or the conductor can be connected mechanically with the carbon cylinder and the union perfected by electroplating. The active agent of the cell may be any of the oxides, salts, or compounds of elements by the decomposition of which oxides, salts, or compounds carbon will be attacked at high temperatures.

A fusible oxide may be used, such as oxide of lead, and a flux may or may not be added, according as the melting point of the oxide used is high or low. The action of the cell with a fusible oxide will be explained. The heat of the furnace fuses the oxide at the same time that it raises the carbon to a temperature at which it combines rapidly with oxygen. A reduction of the oxide takes place, the oxygen combining with the carbon and forming carbon monoxide, which passes off and may be conducted to the combustion chamber of the furnace and used for fuel, it being burned to carbonic acid, while the metal or metalloid or other product is carried to the other electrode, being deposited upon the walls of the containing vessel or pot. During the oxidation of the carbon an electric current flows through the circuit of the cell, which current may be utilized in any way desired or serve to charge secondary batteries for future use. The product of the reduction of the oxide may be reoxidized by the ordinary methods and, used over again as the active agent of the cell.

When a compound, either liquid or solid, is used as the active agent which vaporizes before the carbon reaches the high temperature at which it is acted upon by an element of the compound employed, then a closed melting pot must be used capable of withstanding pressure and preventing the escape of the vapor.

When the carbon cylinder becomes considerably reduced in size, it may be removed from the pot and used for fuel, while a fresh carbon cylinder will be put in its place and the active agent will be renewed.

Apparatus suitable for carrying out the process is illustrated in the drawing, in which A represents a suitable furnace and B an iron vessel or melting pot placed partly therein and heated thereby.

C is the cylinder of carbon or carbonaceous material formed as before described and resting on fire-clay block, *a*. The cover, *b*, of the pot is also of fire clay. The circuit connections, 1, 2, are made with the pot, B, and carbon cylinder, C, the latter in the manner before explained.

D represents the active agent or compound of the cell.


EDISON'S ELECTRIC FURNACE.

## LYE TANKS, OIL COOLER, ESCHWEGER SOAP.

In factories requiring large quantities of lye at short notice, as in laundry soap works, the ordinary tanks mostly used now, in which the caustic is dissolved on the bottom of the tanks with the aid of steam, are probably as practical as any lye tank can be. But wherever time is not so scarce, or where an extra lye tank is found cheaper than the use of steam, there the following arrangement may be found to have some very convenient features. The illustration represents a tank of any desired size and shape. At a convenient height a grating or false bottom, A, is provided, which may be made by a number of iron bars being placed crosswise over each other so as to form two layers at right angles to each other, and resembling a sieve. The drums of caustic, B B, with their covering removed are rolled down a chute and lie on the grate. Water is then run in until the caustic is just covered. As the soda dissolves, the heavy lye always goes to the bottom and the weaker lye rises to the top to become more saturated, and consequently no steam is required at all to make the lye, as when all the soda is dissolved the lye will be of the same strength throughout the tank. Neither is it necessary to break up the caustic first. All that is necessary is to find by the first few trials just how much water must be in the tank and how much soda, to make lye of a certain strength.

For making cold soap, as is well known, the lye should be as caustic as possible, and in order to keep it from absorbing carbonic acid from the air, and thus losing part of its causticity, some soap makers cover the tank and place some quick lime over the top. It stands to reason that this is neither convenient nor even very effective. A way which I have found to be

much handier and more thorough is to simply throw a quantity (according to size of tank) of mineral soap stock in the lye tank. This soap stock, as it cannot be saponified, will always swim on top of the lye and exclude the air from it very effectively.

A handy addition to a lye tank, which may also be profitably made in the case of an oil tank where large quantities of oils and fats are bleached and then used for cold soap, is an arrangement for hastening the cooling off of the lye (or oils, as the case may be). It consists simply in placing in the tanks a suitably formed pipe or coil through which cold water is made to run. When you have bleached a large quantity of fats, this pipe will save you considerable time in waiting for the fat to cool sufficiently for use in cold soap.

And now for a few words on that pride of the German soap makers, "Eschweger Seife." This is a soap which is considered the most difficult to make of all the German soaps, but it has taken the place of the old tallow curd soap, and in fact is sold there the most largely of all hard soaps. Consequently all the soap boilers have had to make the best of their skill in making this article. How this may be to-day I do not know, but some years ago a manufacturer in Dresden, Louis Kuentzelmann, had an unrivaled reputation in this soap. He made it by what they call the "indirect" process, as follows: 2,000 pounds of palmseed oil and 1,000 pounds of tallow were saponified and grained with salt. (Palmseed oil is used there largely and stands in its properties intermediate between the tallow and cocoanut oil.) The spent lye was then run away and 1,000 pounds of palmseed oil were again added, together with sufficient lye at 20°, and boiled, to close up the soap. This made a whiter and finer soap than any other manufacturer made at the time. 100 pounds of fat give about 185 pounds of soap, but the "artists" have not been idle who make a specialty of filling soap to the highest point, and many pride themselves on being able to make the same amount of fat do for 400 pounds of soap, by filling with salt water, potash solution, silicate, French talc, potato flour, etc.

Another method of making Eschweger soap is the "direct" process, in which the materials are boiled on a close change, without any separation whatever. A fair example of it is as follows:

3,000 lb. tallow.
1,000 lb. cocoanut oil.
500 lb. rosin, W. W.

The fat is boiled altogether with 30° lye, the amount of which must be so gauged that at the end of the operation the soap is perfectly neutral. If the soap is strong, it will settle and has to be worked over again (this is the dread of the soapmaker half the time); if too weak, it will not produce the mottle on which the appearance and sale of the soap largely depends (and which the soapmaker dreads the other half of the time). In fact, a soapmaker who could make this soap uniformly successful was a great rarity, and is so probably to-day. For the mottle 12 lb. of iron ore or copperas is added to 1,000 lb. of soap, or if wanted blue, then ultramarine. When the soap is too strong, the fact is indicated by a sample on a glass having a gray ring around its edges. When neutral, a wooden trowel sunk into it and immediately withdrawn will have thick clots of soap hanging to it, with little patches between the dots that show the smooth trowel. From the clots of soap a thin skin can be pulled off with the finger almost immediately after taking the sample, and even if the soap is neutral it will not mottle if the lye used is *too caustic*. In such a case the soap, when half cold, will appear rubber-like; this can be helped by adding carbonate of soda, or if the mottle is required to be large, by adding pearl ash and a little salt, but *very little* only. To experimenters I should recommend the use of open fire, as the soap is very difficult to make by open steam, and few kettles are able to give enough heat by closed steam pipes, as they are used in this country.—*H. N. D., in Amer. Soap Jour.*

## THEORY OF DRYING.

The Philadelphia Textile Machinery Co., Philadelphia, Pa., give the following remarks: It is universally known by all those who have anything to do with drying for any purpose that the rapid circulation of air about the goods or material being dried quickens the process, and that the hotter the air is, the faster the drying; but the precise manner in which the drying is accomplished is not so generally understood. One of the erroneous theories commonly entertained regarding the method by which the drying is accomplished is that the air in itself is the element which does the work.

Some maintain that the air absorbs moisture on about the same principle that a sponge absorbs water, by capillary attraction. Somehow the heating of the air increases the power of that attraction, and by circulating the air, the air which has performed its work of absorption is removed and fresh air is brought into contact with the goods to continue the process, just as if one sponge did not take up all the water in a puddle, another sponge could be used.

Others maintain that the air takes up the moisture about as sand or sawdust is used to dry up oil or water. Each particle of air being dry on coming in contact with the damp goods becomes more or less moistened, and, on being removed, it takes the moisture away with it. Heat makes the particles of air drier, so that they can take up more moisture, and, of course, the faster the dry particles are supplied by circulating the air, the quicker the total quantity of moisture in the goods is carried away.

These theories sound very plausible, but they fail to adjust themselves to all the facts observed in connection with drying. For instance, it is found that drying is done much quicker and with less heat in a rarefied atmosphere. Thus, with the same amount of heat applied, water will evaporate more quickly on the top of a mountain, where the air is rare, than at the sea level where it is dense. Water requires to be heated to 212° to reach the boiling point at sea level under a pressure of 15 lb. per square inch, but at an altitude of 6,300 ft., under a pressure of only 12 lb. per square inch, water will boil when heated to only 200°. Hence, it would appear that the process of drying, or evaporating, is hastened by having a lesser density, and consequently fewer particles of air in contact with the water. This is opposed to the theories advanced. In some manufactures, as in the drying of lumber, etc., this fact is taken advantage of, and the material to be dried is placed in closed iron retorts, or vessels, from which the air is exhausted, and it is found that the drying proceeds more rapidly than in the ordinary atmosphere, the rapidity of the drying being in proportion to the degree to which the air is exhausted. The method of drying by exhaustion would be more generally resorted to were it not for the expense of the apparatus and the cost of its operation, which is necessarily an important factor in that process. From what has been said it would appear that the presence of air hinders the drying process, since drying is done more quickly and with less heat in proportion to the degree of rarefaction obtained.

Now this is exactly the case; *air in itself does not help in any way, but on the contrary hinders the process of drying.* All drying is accomplished by the evaporation of the water contained in the goods. Evaporation, strictly speaking, is that process by which water assumes the vaporized state at its free surface, and is a process dependent on conditions within the water itself, but independent of conditions, as of the atmosphere, outside of the water, except so far as those conditions favor or hinder the escape from the wet surface of the vapors which have been produced as a result of evaporation. Evaporation, in general terms, has a much broader meaning, being understood to cover the entire process of, and to be nearly synonymous with, drying, but we must here limit the meaning of the word evaporation to the more scientific definition given.

The process of drying may, therefore, be divided into two distinct parts or sub-processes, the transformation of the water into vapor and the removal of the vapors after being formed.

Heat alone is the element by which water must be converted into vapor. In order to understand this, brief reference must be made to the dynamical theory of the constitution of bodies. According to this theory, all bodies, whether solid, liquid, or gaseous, are composed of minute particles called molecules. These molecules are in a more or less rapid state of motion. This motion is called heat. Heat, then, is simply molecular activity within the substance of a body. We have here to do with liquids and gases only, and will therefore not say anything in regard to the molecular movements of solid bodies. In a liquid the molecules are continually moving about among themselves, assuming new positions and traveling from one part of the mass to another. The energy of these movements in the same liquid depends upon the amount of heat in the liquid, *i. e.*, its temperature. The molecular movements of the substance of a vapor or gas are of far greater activity than those of a liquid. When a liquid is converted into a vapor, there is a sudden and remarkable increase in molecular activity, so that the molecules of the vapor, while being the same molecules which composed the liquid, on assuming the gaseous state become instantly endowed with an amplitude and with a speed and rate of movement many times greater and more intense than the movements of the same molecules when in the liquid state. The energy of the movement of the gas is, like that of the liquid, dependent upon its temperature.

We are now prepared to understand the process of evaporation. When a particle of water in the course of its wanderings reaches the bounding surface with more than a certain normal velocity, it is able to pass through the surface and get quite clear of the liquid, when it becomes a particle of vapor. As soon as the particle leaves the surface it becomes endowed with the molecular activity of a gas, by virtue of which it works away from the surface in accordance with the princi-

ples of diffusion of gases. The number of particles passing through a given area from the water will depend upon the velocity of the liquid particles, and therefore upon the temperature of the liquid, but it will be entirely independent of the condition of affairs outside the liquid. Now if there was no hinderance due to the presence of a medium, generally air, or the vapor of the liquid itself, outside of the liquid, the whole mass of the exposed water would be converted into vapor with a celerity with which we are wholly unacquainted. As it is, the pressure of the air above the water hinders the diffusion of the vapors just formed, thus causing the portion of the vapor nearest the surface of the water to approach more nearly to the state of saturation than would otherwise be the case, and the rate of evaporation will be diminished.

Not all of the particles which escape through the surface are diffused in the air, but part of them are precipitated back again by rebounding from contact with the particles previously escaped and with the particles of air. Whenever a particle of vapor moves toward the surface of the liquid and reaches it, it enters the liquid and is condensed. It is only those particles which succeed in getting away from the surface that constitute the effective evaporation.

The rapidity of evaporation therefore depends upon the degree of temperature of the water in the goods, and it matters not how that heat is conveyed to the water, whether by contact with a heated surface, as when cloth, paper, etc., are passed against the surface of revolving heated drums, or by exposure to radiation from fires or from heated surfaces, as steam pipes, or whether, as is more generally the case, the goods are immersed in an atmosphere made artificially hot for the purpose, in any and all cases *the water or moisture to be evaporated must be made hot*, if rapid drying is to be accomplished. While it matters not how the heat is conveyed to the moisture, so far as the evaporation is concerned, some of the methods described for applying heat present better facilities than others for the escape of the vapors from the wet surfaces.

It is evident that no process of drying affords so extended an evaporating surface, or such complete facilities for removing the vapors of evaporation, as when goods are exposed on all sides to the air, such as may be attained by hanging in the air, or by spreading on wire nettings, etc., and causing currents of air to freely pass over, through or among the goods, so as to rapidly carry away the vapors. In practice such currents are made hot for the purpose of conveying heat to the goods, thereby heating the moisture contained, or, when goods are dried by pressing against hot surfaces or by direct radiation, to avoid cooling such surfaces or the goods and moisture, and in order not to condense the vapors formed.

We find then that air is not a drying medium, but only an incumbrance to any drying process, which cannot easily be avoided, but which may be used in certain ways so as to mitigate the evils of its presence.

## NEW SOUNDING APPARATUS FOR SUBMARINE RESEARCHES.

THE methodical study of oceanic depths has given rise to an exact science, which is wholly modern, and, so to speak, of the present day—the science of oceanography, of measurement and experimentation (to use the very words of one of the most authoritative masters in the matter, Mr. J. Thoulet), in which there are required special instruments without which it could not exist. Most of these apparatus, simple in appearance, present, in reality, great difficulties of execution. Nothing seems easier than to effect a sounding; a leaden weight is fixed to a rope, then it is allowed to descend, and as soon as it comes to a standstill, the rope paid out is measured. When the operation is performed in a deep sea, the rope runs out indefinitely without communicating any shock, and when an effort is made to draw it up, it breaks.

In order to suppress, to as great a degree as possible, such causes of errors, which have already occasioned so many disappointments, powerful apparatus have been constructed, the majority of which require a costly installation, numerous expert employes, and geared windlasses actuated by steam power.

Unfortunately, every one has not, like the great official expeditions of the Blake, Challenger, and Talisman, or of the Pola, powerful means of action at his disposal. And, unless they are like Prince Albert of Monaco, private individuals do not usually own a steamship provided with a scientific equipment installed (with all the precision required by modern processes) by naval engineers such as Mr. Thibaudier or constructing engineers such as Mr. J. Le Blanc.

These considerations, joined to the necessity of having, for our personal use, accurate and simple instruments of extreme lightness designed for the researches that we have long been pursuing in high mountain lakes, especially in Lake Oo, and Lake Oredon (Central Pyrenees), where we received the kindest reception on the part of engineer in chief J. Fontes, have led us to devise a small sounding apparatus capable of winding up 350 meters of steel wire and weighing less than four kilogrammes, and consequently less than most of the photographic apparatus in use.

The results obtained and a desire to be of service to hydrographic engineers, mariners, explorers, and all those who occupy themselves with oceanography, decided us to study a new form of apparatus based upon the same principle, but slightly enlarged, stronger, and combined for every application that can be required of an apparatus designed for submarine researches.

The plans of this new sounder we were enabled to present to his Highness, Prince Albert of Monaco, during the period of the scientific equipment of his new yacht the Princess Alice, thanks to the intervention of Baron Jules de Gerome. The Prince having had one of these apparatus constructed, his example was immediately followed by a most distinguished engineer, Mr. A. Delebecque.

The following is a description of the apparatus. A frame formed of two bronze cheeks (Figs. 1 and 2), connected by cross bars, is firmly fixed to a horizontal piece of wood, which serves at the same time as a bottom to the packing box designed to protect it during carriage and as a base to the machine. The dimensions of the box are 0·30 m. × 0·45 m × 0·5 m. The apparatus weighs 20 kilogrammes.

A drum, A, keyed upon the main shaft of the machine is capable of winding up about 2,000 meters of ⅕ mm. steel wire, or 1,100 meters of ⅘ mm. wire. Each extremity of the shaft is arranged to receive a winch, although a single one suffices, in most cases, for hoisting the weight. To the right of the drum, and forming a part thereof, there is a ratchet wheel that permits of stopping the descent of the weight at any depth. At the left there is a channel that receives a brake spring designed to render the unwinding of the wire regular and to signal automatically the precise moment at which the weight touches bottom.

The pressure of the brake is regulated by means of the lever, M, and its accessories, so that, for example, a traction of from 5 to 10 kilogrammes exerted at the extremity of the sounding line gives sufficient liberty to the drum to allow the wire to unwind without difficulty.

To the stress exerted at the extremity of the line there corresponds a traction upon the pulley, C, which raises the lever, L, and causes it to oscillate around the axis, O. As soon as the lead reaches the end of its travel, the line being freed from all the tension that the weight of the lead makes it support, the corresponding traction upon the pulley ceases, the action of the spring, R, makes itself immediately felt, and the brake is tightened. Then, as the wire is no longer able to unwind, the operator reads upon the graduated counter, fixed upon the axis of the metric pulley, D, the depth reached by the lead.

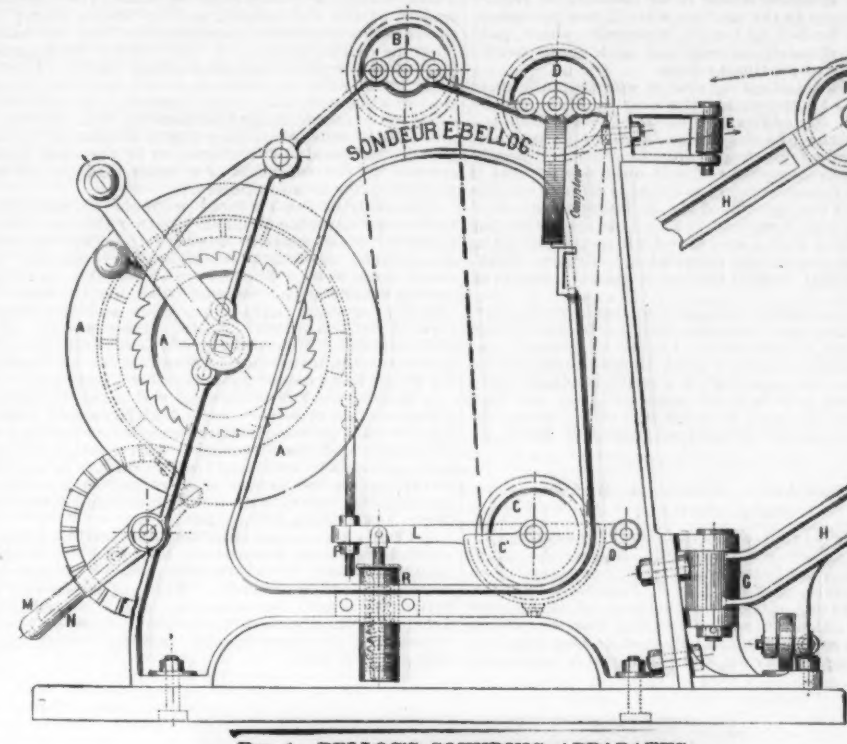


FIG. 1.—BELLOC'S SOUNDING APPARATUS

On leaving the drum, the wire first passes over a wheel, B, and then over a wheel, C, placed at the lower part and entering a trough containing a substance of a nature to prevent oxidation of the wire. This wheel, C, is supported by a lever, L, of which the object is to act upon the brake in order to apprise the operator of the fact that the weight has reached bottom.

The wire afterward engages in the channel of the metric pulley, D, which it completely envelops before passing between the two cylinders, E, which are surrounded with thick felt and which serve to guide and dry it during the ascent. Finally, it reaches the pulley, F, over which it bends nearly at right angles above the point at which the weight is to be immersed.

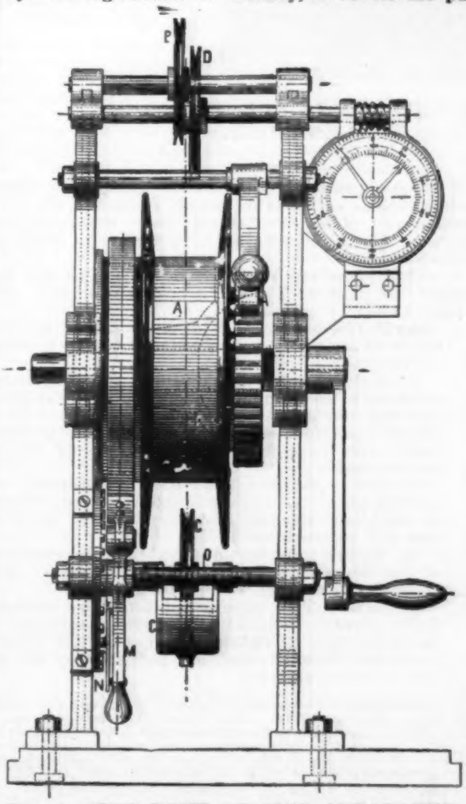


FIG. 2.—SIDE VIEW OF THE APPARATUS.

The more or less violent shocks that the motion of the waves imparts to the boat are reduced by the lever, L, and the spring, R, and the object of the guiding of the wire over the wheel, C, is to permit of the automatic tightening of the brake and the stoppage of the machine at the very moment the lead touches bottom.

The diameter of this pulley is so calculated that each of the divisions of the external circumference corresponds to a depth of 0·1 of a meter, and each of those of the interior circle to a depth of 10 meters. The arm, H, may be detached from its point of support, G, in order to facilitate carriage. A very simple arrangement permits of changing its direction to the right or to the left, and of making it stationary, at will, at any point whatever of the arc of a circle of 180 degrees that it is capable of describing horizontally.

As this arrangement permits of bringing the arm alongside of the vessel, or even inside of it, it has the advantage of doing away with the necessity of leaning over the side of the vessel in order to attach the different instruments that the wire is to receive.

In order to lessen friction, the pulleys are made of bronze, while the axles are of steel. The latter are calculated to support a stress not greater than two kilogrammes per square millimeter.

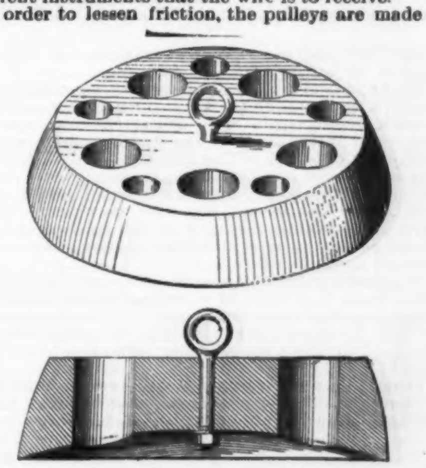


FIG. 3.—SOUNDING LEAD, ELEVATION AND SECTION.

During its descent the wire may unwind at the rate of four or five meters per second without there being any fear that it will slide around the pulleys; but if, by accident, a sliding should occur, the operator would be notified of it by the revolution counter.

As the above brief description shows, this machine is very simple. Reduced to a minimum of weight and volume, it may be put to very numerous applications, for it is adapted for all the scientific experiments to which the natural phenomena of water may give rise, whether it be a question of fixing the limits of the thermic regions, of studying actinic transparency, of laying out bathymetric maps, or of studying topographically the bottom of lakes or seas. In a more practical direction, it permits of making soundings at the mouth of rivers, of taking the sinuosities of a

channel obstructed by sand, of recognizing a channel, or of tracing the profile of an anchoring ground with a shifting bottom.

In addition, it may serve for measuring any vertical height whose summit is practicable and whose base is difficult of access, like that of an escarpment or of a cliff falling perpendicularly into the sea, of a bridge thrown over a torrent, of a mine shaft, etc.

Apart from the scientific studies to which it may be applied, this machine seems to be destined to render valuable services to the marine, were it but to replace the cordages formed of textile materials, which, paid out by hand, elongate or contract and consequently furnish merely approximate data.

Finally, this sounding apparatus, constructed under the direction of constructing engineer G. Eude, can be used with all the ordinary sounding leads, provided that their weight does not exceed 15 or 18 kilogrammes.

But for exclusively topographical work, especially where the bottom consists of soft mud, a spherical is preferable to the elongated form that is often given the lead. Such is the opinion of Mr. J. Thoulet, and such also are the considerations that led us to devise the weight shown in Figs. 3 and 4, and which appears to us to answer the conditions required for effective work. It is a discoidal weight having a slightly incurved bottom.

Cylindrical apertures designed to diminish the surface of resistance, and consequently the friction of the water, traverse it vertically. Owing to these, it descends more rapidly than a solid sounding lead of the same weight. As its center of gravity is placed very low, it does not sink into the mud, and does not turn over upon its side, and it is not apt to roll along declivities or the sides of submerged rocks.—*E. Belloc, in Le Genie Civil.*

## PHOTOGRAPHY UPON A BLACK BACKGROUND.

THE principles that we have several times enunciated on the subject of photographic operations upon black backgrounds have been turned to account. Two young operators, Messrs. P. & F. Leprince, have recently sent us one of their productions, which appears to us so very successful and so pleasing that we have no hesitation in reproducing it. As may be seen from the accompanying engraving, the photograph represents

REPRODUCTION OF A PHOTOGRAPH OBTAINED BY THE UTILIZATION OF A BLACK BACKGROUND.

a little girl drawing a wagon containing an enlarged head of her brother.

The exposure, says Mr. P. Leprince, was made in the shade in front of a house whose open door served us as a black background. The apparatus that we used was made by Jonte, and was provided with a rapid rectilinear objective. The first exposure, that of the wagon and the child drawing it, was made as in an ordinary photograph, at a distance of about seven yards. For the second exposure, in which it was a question of taking the head of the subject properly placed before the open door, the apparatus was moved forward about three feet.

We placed in front of the objective, and at some distance from it, a sheet of black cardboard held by a support, containing an aperture, and forming a screen, so that there was received upon the plate only the image of the head standing out from the black background.

From this new example, it will be seen that black backgrounds offer operators valuable resources for the taking of amusing photographs.—*La Nature.*

[Continued from SUPPLEMENT, No. 825, page 13190.]

## PHOTOGRAPHIC CHEMISTRY.*

By Prof. R. MELDOLA, F.R.S.

### LECTURE II.

CONTINUING the study of those properties of silver salts which are of photographic importance, the next point to be dealt with is the vexed question of the existence of sub-salts. Here, in the present state of knowledge, it is most advisable to avoid dogmatic statements. The utmost that can be done is to summarize the evidence, and to let the student see therefrom that, from a scientific point of view, the existence of such sub-salts has not been conclusively demonstrated. To all who are familiar with the course of investigation in this direction, it will be evident that the current statements in text-books, and which are repeated in the photographic manuals, must be taught with due caution. I have no time to go over the whole of this familiar ground again, and I must

* Lectures before the Society of Arts, London, 1891.—*From the Journal.*

content myself by giving references.* I will only repeat now what I said some years ago, viz., that so far as analogy is to be trusted as a guide, it would seem improbable that the sub-haloid salts of silver should be highly colored compounds, because the analogous salts of copper, mercury, and thallium are not highly colored.† Now, all the attempts which have been made to produce sub-haloid salts of silver by partial reduction or by other methods give rise to colored products, which have been held by some investigators to consist of the sub-haloids, and by others (Carey Lea) to consist of molecular compounds of the sub-haloids with the haloids proper. It may further be suggested that these colored compounds might consist of oxyhaloids, mixed or combined (molecularly) with the haloids, that in some cases they might consist of metallic silver or its oxide in molecular combination with the haloid, and that in other cases they might consist of the foregoing compounds or mixtures, or of the true haloids colored by the retention of a small quantity of some metallic oxide as an impurity.‡

The study of these colored products is of importance to the photographic chemist, whether they are definite chemical compounds or whether they are molecular compounds, or whatever subsequent research may prove them to be. They are of importance to us here, among other reasons, because there may be some relationship between these compounds and the products formed by the photochemical decomposition of the silver haloids. I have thought it desirable, therefore, to summarize, in a collected form, the various methods by which these compounds have been produced:

1. Rose-colored silver chloride; obtained by reducing a hot solution of silver citrate with hydrogen, exhausting the dark product (before complete reduction) with citric acid, and then treating it with hydrochloric acid. Obtained also by reducing the dry nitrate in hydrogen at 100 deg. C., extracting the product with water and treating the residue with hydrochloric and nitric acids. (Brit. Assoc. Rep., 1859, p. 105.)

2. Chocolate-colored chloride; obtained by adding a solution of silver arsenite in nitric acid to a strong boiling solution of caustic soda, when "an extremely black powder" is produced. This, on treatment with hydrochloric acid, becomes gray, and the washed product, on boiling with dilute nitric acid, loses silver and leaves the chocolate-colored chloride. (Brit. Assoc. Rep., 1859, p. 106.)

3. Colored products obtained by acting upon silver with solutions of ferric or cupric chloride have long been known. (Becquerel's films; see G. Staats in Ber. Deutsch. Chem. Gesell., 1887, p. 2322, and 1888, p. 2199.) §

4. Colored products obtained by Carey Lea, and described as "photochloride," "photobromide," and "photoiodide" ("photosalts").

(*a.*) Purple or black chloride, obtained by the action of alkaline hypochlorites on finely divided (reduced) silver.

(*b.*) Red chloride, prepared by adding ferrous sulphate to an ammoniacal solution of silver chloride and then acidifying with dilute sulphuric acid. The precipitate is washed, boiled with dilute nitric acid, washed, and finally boiled with dilute hydrochloric acid.

(*c.*) Red or copper-colored chloride, prepared by heating silver oxide or carbonate to a point short of complete reduction, and then treating the residue with hydrochloric acid.

(*d.*) By precipitating silver oxide in the presence of the lower oxides of iron, manganese, etc., and treating the product with hydrochloric acid.

(*e.*) Dark purple chloride, obtained by treating finely divided (reduced) silver with a solution of ferric-chloride. (Contains 76·07 per cent. of silver.)

(*f.*) Red chloride, similarly prepared by the action of cupric chloride.

* See "Chemistry of Photography," Lecture I., p. 39 *et seq.*; also *Nature*, vol. xliii., p. 246 (July 10, 1890). A brief historical summary will also be found in Carey Lea's paper on the allotropic forms of silver, already referred to. Some of the earliest experiments on this subject were made by Wohler, and will be found referred to, together with much additional work, in a report published by a British Association committee in 1859.

† Thallous iodide is yellow, and mercurous iodide greenish yellow.

‡ Since the delivery of the lecture M. Guntz has contributed a paper to the "Comptes Rendus" (vol. cxii., p. 861), claiming to have isolated the sub-haloids by preparing, in the first place, the sub-fluoride by the electrolysis of a saturated solution of silver fluoride. By the action of HCl, HI, $H_2S$, $H_2O$, etc., on the sub-fluoride, the other sub haloids, and the sub-oxide, $Ag_4O$, are said to have been prepared (see *Nature*, April 30, 1891, p. 620). Seeing the tendency possessed by fluorine compounds to become polymerized, it is, however, by no means certain that the "sub-fluoride," which is described as a crystalline powder resembling bronze filings, has the simple formula $Ag_2F$.

§ The colored films produced by this method do not always owe their tints to the formation of a colored product of the nature of a pigmentary coloring matter. The chromatic effect is, in many instances, purely optical, *i. e.*, due to the phenomenon of "thin plates." The colored spectra recently obtained by M. Lippmann are of the same nature; see Berget's "Photographie des Couleurs," Paris, 1891.

(*g.*) Red chloride, prepared by pouring dilute solution of silver nitrate on to cuprous chloride, and boiling the black precipitate thus obtained with dilute nitric acid.

(*h.*) Brownish purple chloride, prepared by pouring an ammoniacal solution of silver nitrate into a strong solution of ferrous chloride, and treating the dark precipitate with dilute sulphuric acid. Becomes lighter with nitric acid. (Similar to *b.*)

(*i.*) Purple chloride, prepared by reducing the citrate in a current of hydrogen at 100° C., and treating the product with hydrochloric and nitric acids successively. (Similar to No. 1.)

(*j.*) Red and purple shades of chloride, obtained by reducing (partially) a silver salt with alkali and an organic reducing agent, such as milk-sugar, dextrine, etc., and then treating with hydrochloric and nitric acids successively.

(*k.*) Red, brown, or lavender chloride, produced by treating the white chloride with a boiling solution of sodium hypophosphite. The dark, chocolate-colored product is washed, and boiled with dilute nitric acid.

By somewhat similar methods, colored forms of the bromide and iodide have been obtained; but it will be unnecessary to trouble you with the details, as these will be found in the original papers. (See "Amer. Journal Sci.," vol. xxxiii., May and June, 1887, and vol. xxxiv., July, 1887.) It is quite easy for the student of photographic chemistry to repeat some of these experiments, and to prepare some of the colored products. Especially simple are the processes *b*, *g*, *h*, *j*. The repetition of these experiments will not only be useful as practical exercises, but they will serve to enlarge the ideas of the worker with respect to such familiar compounds as the silver haloids, which, in ordinary work, are generally regarded as mere tests for the halogens, and to show him that a wide domain for exploration lies beyond the region of his ordinary chemical experience. In this connection, also, it is desirable to call attention to the tendency of the silver haloids to retain traces of other chlorides, such as those of iron (ferric), cobalt, manganese, nickel, copper, etc.*

From these special studies of the silver compounds we may now pass to another phase of the subject, viz., the combination of silver and its salts with organic compounds. At this stage the technology, *i. e.*, the sources and methods of manufacture of the more important organic compounds used by the photographer, may be conveniently introduced. The ordinary organic acids, such as acetic, oxalic, citric, tartaric, etc., will of course have been dealt with in the preliminary training, but in addition to these special attention should be directed to the chemistry and technology of cellulose (including paper, collodion, and celluloid), albumen, and gelatine. Let it be realized in the course of this work that albumen is of the nature of an acid forming salts with various metals. Show the precipitation caused by such salts as those of mercury and silver. Let the precipitated "albuminate" of silver be collected, washed, and dried, and then the presence of silver proved by burning some of the compound, extracting with dilute nitric acid, filtering, and testing in the usual way. The similar tendency of gelatine to combine with silver compounds is very striking, and of fundamental importance to the photographic technologist. The best way of approaching this is to let the student make experiments for himself. A sheet of gelatine can be prepared by coating a glass plate with a warm, strong solution of the substance, and allowing it to dry for some days in a warm place. When stripped off, the film is floated for some hours on a solution of silver nitrate, then removed and washed with water. It now remains to be shown that silver in some form or other has actually been withdrawn from the solution, and has entered into combination with the gelatine. In order to prove this, some of the gelatine compound can be dried, and burnt, and tested, in the same way as the "albuminate." The "gelatino-nitrate" can also be proved to darken on exposure to light. An experiment of this kind will prepare the way for the all-important subject of the preparation of emulsions.

The proportions of materials and the various technical details are fully treated of in all works on practical photography, and need no special description in these lectures.† The first point to which attention must be called is the nature of an emulsion, and the influence of the vehicle in keeping the silver haloids in suspension. An easy experiment will bring this home to the student. To a solution of common salt or some soluble bromide add some silver nitrate, and notice the immediate separation of the silver haloid on agitation. Now take some of the same salt solution, add a little strong gelatine solution to it, mix by agitation, and then again add some of the same silver nitrate solution. It will be noticed that the separation of the silver haloid takes place more slowly, and that when formed it does not subside as in the previous experiment, but agitation simply helps to make the contents of the vessel (now an emulsion) more uniform. A similar experiment may be made with ordinary alcohol and ether containing a soluble haloid ($ZnBr_2$, or $CdBr_2$), and then, by way of comparison, with the same alcohol and ether containing dissolved pyroxlin (collodion).

By such experiments as these the principle of emulsification will be clearly brought out. The student should, in connection with these experiments, be well practiced in calculating the necessary quantities of the different haloids for precipitating given weights of silver nitrate. At this stage the practical preparation of emulsions might well be commenced, and plates should be coated with gelatino-bromide emulsions prepared in accordance with any of the adopted formulæ. This should at first be carried out with the object of imparting skill in the *technique* of the operations, the scientific reasons for having an excess of soluble bromide and for washing out excess of soluble salts being explained in the course of the work. These explanations will of course only be fully appreciated after the action of light upon the silver haloids has been dealt with, and the practice of emulsion making can, if thought desirable, be deferred to a later period.

In the same way that the compounds of silver are

* Carey Lea, "Amer. Journ. Sci.," vol. xxxiv., p. 384.

† Abney's works are of course familiar to all practical photographers in this country. The latest edition of Dr. Eder's "Photographie mit Bromsilber-Gelatine," etc. will be found invaluable to those who can read German.

prepared and studied, the other photographic materials should be dealt with. Their ordinary chemical properties should be familiar to the student, not only through reading or attending lectures, but by laboratory work. His knowledge should be as wide as possible, and should embrace the compounds of iron, chromium, manganese, uranium, copper, mercury, platinum—in short of all the metals having any connection with photography; and it is hardly necessary to add that the special uses of any of these compounds in photographic processes should be dwelt upon exhaustively. To this knowledge it is desirable to add an acquaintance with the formulæ and mode of preparation of the reducing agents, both inorganic and organic, used for development, such, *e. g.*, as hydroxylamine, pyrogallol, hydroquinone, eikonogen, and so forth.

Armed with this general chemical knowledge, specialized in the direction of his subject, the student will be in a position to proceed to the particular kinds of decomposition, viz., photochemical, upon which the art of photography is based. This part of the subject must also be dealt with as broadly as possible, for it is of the utmost importance that the principle should be realized that the photochemical decompositions made use of in photography are but particular instances of a general class of such decompositions some of which are at present not available for photographic purposes. It must be pointed out that a study of some of these collateral decompositions is likely in the future to lead to results of practical value, and may certainly be expected to throw great light on the nature of the photographic image.

The broad distinction between purely physical changes induced by light and actual photochemical decomposition may be maintained, although it is often difficult to refer a particular case to one or the other of these classes. Complete lists of all the known instances of the physical and chemical action of light will be found in the works of Eder and Vogel,* but it is advisable, in treating the subject as a branch of chemical technology, not to bewilder the student, at first, with a vast array of facts, but rather to enforce general principles by a few well-chosen illustrations which the student can work out for himself without much difficulty. The simplest kind of photophysical action is that which produces a change in molecular structure, either temporary or permanent. In connection with this, the action of light upon selenium is perhaps the most striking illustration that can be given, and where the necessary apparatus is at hand, it would be well to demonstrate the point experimentally in the usual way. As examples of permanent change of molecular structure, the modifications in crystalline form undergone by certain substances on exposure to light may be appealed to and illustrated. The following experiments can be easily done in the laboratory:

1. A saturated solution of sulphur in carbon disulphide is prepared, and two or three tubes are filled with the solution and sealed up. The contents of a tube kept in the dark will remain clear for an indefinite time, but on exposing one of the tubes to sunlight, the contents become turbid and a gradual separation of insoluble sulphur crystals will take place.

2. A plate of glass is coated with a silver mirror by any of the usual methods of chemical reduction. The mirror is iodized by exposure to the vapor of iodine,† and then exposed to bright light (electric arc or sunlight) for ten or fifteen minutes, one portion of the film being protected by a dark paper screen. The film is semi-transparent at first, but, after the experiment, it will be found that the exposed portion has become yellower and more opaque than the screened portion, the change being apparently due to a physical modification of the silver iodide.

Such experiments as these will serve to impress the mind with the fact that light can cause purely physical changes. Attention may be called to the existence of other changes of a like nature, such as those which occur in red cinnabar, in red realgar, in the crystalline form of nickel sulphate and zinc selenate, etc. From cases of this kind we are led, in the next place, to other changes, which serve to connect photophysical with photochemical action, viz., photopolymerization. The meaning of the term polymerization will be familiar to the chemical student. It must be pointed out that many of the changes in crystalline form, etc., alluded to in connection with the previous examples, may be really cases of photopolymerization or depolymerization. Then the known cases of the polymerization of organic compounds, such as anthracene to paranthracene, styrene to metastyrene, vinyl bromide, thymoquinone to an insoluble modification,‡ and so forth, may be dealt with and illustrated, as far as possible, experimentally. Pointing out, by way of caution, that it is often very difficult to discriminate between photopolymerization and photo-oxidation, the action of light upon asphalt and bituminous substances may be taken as an illustration of the difficulty in question; and a study of the action of light upon such films will naturally lead to the various heliographic processes based upon the original method of the elder Niepce. How far it is desirable to lead the worker in this direction from the practical side must, of course, be determined by circumstances.

The action of light upon asphalt and similar substances is not only of practical importance, but its scientific aspect is worthy of the most serious attention, both by the student and the investigator, who, after all, is himself only a student at a somewhat more advanced stage of his studies. There is some doubt at present whether the insoluble asphalt resulting from the action of light is a polymeride or whether it is a product of photochemical oxidation. According to some authorities, the change does not take place in a vacuum, neither in nitrogen nor in hydrogen. On the other hand, it is stated by Kayser, in favor of the polymerization theory, that no increase of weight occurs in the film, that the insoluble asphalt is converted into the soluble form again by fusion, and that a solution of asphalt in a closed vessel also deposits the insoluble modification on exposure to light. The decision of this point rests with future investigators, but certain facts have been discovered with respect to the constituents of asphalt which must be emphasized in connection with photographic chemistry. It has been found that Syrian and Trinidad asphalt contain a small quantity (4 to 5 per cent.) of a substance soluble in alcohol and insensitive to light, another portion (44 to 57 per cent.) soluble in ether, and a residue insoluble in ether, varying from 52 to 38 per cent. The portions soluble in alcohol and ether, and the insoluble residue, all contain carbon, hydrogen and sulphur; and Kayser, who has investigated these compounds, has gone so far as to assign formulæ to them. The portion which is soluble in ether is sensitive to light, but not so sensitive as the insoluble residue, which contains the constituent of the greatest value for the heliographic processes. The practical outcome of these investigations has been the preparation of a high quality asphalt, consisting essentially of the portion insoluble in alcohol and ether. It may be added that the property of becoming insoluble in hydrocarbon oils on exposure to light does not appear to depend upon the constituent containing the sulphur, as some specimens of asphalt from different parts of the world, which possess the same property, have been found on analysis to be free from sulphur, and to consist of hydrocarbons only.

Before leaving these facts concerning asphalt, I should like to point out that there is a promising line of investigation here, which would well repay a few years' patient work, even if it led to no practical result. I am inclined to believe, however, that the results would be of practical value, and especially in the direction of increasing the sensitiveness of the asphalt film. Asphalt is a complicated mixture of hydrocarbons, etc., and it is probable that the sensitiveness is due to a few or possibly to only one of its constituents. It would be worth while, therefore, to make a further series of experiments having for their object the isolation of the sensitive constituents. I need hardly pause to point out of what immense value it would be to have a bitumen film possessed of a sensitiveness approximating only to that of the silver bromide emulsion.

From these cases of photophysical action, of polymerization, and of possible photochemical oxidation, the study of true photochemical decomposition may be taken up. On account of the comparative simplicity of their decomposition, the salts of iron lend themselves admirably for demonstration at this stage. The study of the ordinary chemical reactions of iron salts will have prepared the way. Having shown how reducing agents convert ferric into ferrous salts, let it be demonstrated experimentally that many organic compounds, such as alcohol, oxalic acid, etc., do not immediately reduce ferric salts. It must then be pointed out that these organic compounds are susceptible of oxidation by ferric salts under the influence of light—that they are in fact potential reducing agents. This can be done in test tubes or flasks in the first place, and then on paper films, leading to the ordinary cyanotype and blue printing processes. A few hints for the carrying out of the experiments may be found serviceable:

1. A solution of ferric chloride (2-3 p. c.) mixed with a solution of oxalic acid* will, of course, on testing with potassium ferricyanide give no blue coloration. Some of the same solution, exposed for five minutes or so to strong light, will be found to contain ferrous salt, on again testing with ferricyanide:

$$2FeCl_3+H_2C_2O_4=2FeCl_2+2HCl+2CO_2$$

2. By using ferricyanide with the ferric salt, and exposing to light, the reduction is made visible by the formation of Turnbull's blue. This can be done by adding ferricyanide to the foregoing, or preparing two solutions: one containing 8 grammes of potassium ferricyanide in 50 c. c. of water, and the other containing 10 grammes of ammonio-ferric citrate in 50 c. c. of water. The solutions are mixed before use, and then exposed to light, first in a test tube, and then on paper coated with the solution, and allowed to dry in the dark. The practical application of this method for copying and printing will be obvious.

The chief point of general theoretical importance brought out by such experiments as these is that light only reduces the ferric salts in the presence of oxidizable compounds of sufficient instability. It is advisable, at this stage, to introduce the notion of *sensitizers*, and to point out that oxalic acid, citric acid, alcohol, etc., may be regarded in this light in the experiments referred to. The demonstrations with ferric salts may, of course, be extended in many directions, and made the basis of numerous practical exercises and lessons in the application of general chemical principles to special cases. All that has to be borne in mind is that a surface of an organic salt exposed to light under a stenciled design (or a picture) gives ferrous salt on the exposed portions, leaving the unexposed portions unchanged. Various reagents may then be used to reveal the chemical difference in the two portions, the subject of photographic development being thus introduced, and the changes involved being explained by ordinary chemistry. By way of example:

1. A design printed on paper coated with ammonio-ferric citrate is developed by ferri-cyanide. The exposed (reduced) portions come out blue, owing to the formation of Turnbull's blue. Supposing ferrous citrate to be formed:

$$Fe''_3(C_6H_5O_7)_2+K_6Fe_2Cy_{12}=Fe_3(Fe_2Cy_{12})+2K_3(C_6H_5O_7)$$

The blue design, after being well washed, can be made the subject of many further experiments, all instructive as illustrating chemical principles with which the student should be familiar. Thus on treatment of a dilute solution of caustic soda, the blue is at once decomposed with the formation of $Fe_3O_4$, which remains on the paper. We have thus a faintly visible brownish design, which can again be developed by taking advantage of the property possessed by the oxides of iron of forming colored compounds with organic substances, such as gallic acid, alizarin, nitrosophenols, etc.

2. The design printed on the ferric salt may be developed by taking advantage of the reducing power of the exposed (ferrous) portions and the non-reducing power of the unexposed (ferric) portion. Thus with a solution of silver nitrate:

$$2\,Fe'_2\,(C_6H_5O_7)_2+6\,AgNO_3=$$
$$4\,Fe''\,(C_6H_6O_7)+2\,Fe''\,(NO_3)_2+3\,Ag_2$$

With a solution of auric chloride:

$$2\,Fe'_2\,(C_6H_5O_7)_2+2\,AuCl_3=$$
$$2\,Fe''\,Cl_2+4\,Fe''\,(C_6H_6O_7)+Au_2$$

Similarly with platinic chloride, chromates, mercury salts, and other reducible compounds.

3. Development can also be effected by utilizing the oxidizing property of the unexposed (ferric) portion, and the non-oxidizing power of the reduced (ferrous) portion, such, *e. g.*, as by immersing in a solution of potassium iodide, mixed with starch paste.

Such demonstrations as these cannot fail to give a vivid idea of the effect of photochemical decomposition, and the striking results that can be obtained by the application of familiar reagents. It may be pointed out that the photochemical reduction of ferric salts, although practically useful for printing purposes, takes place too slowly to enable these compounds to be used at present for the production of camera pictures. But there is no reason why the rate of photochemical reduction—*i. e.*, the sensitiveness of these compounds—should not be increased by admixture with some easily oxidizable substance and a sensitive film prepared by this means, which would cheapen photographic processes, by dispensing with the use of silver salts.

In the same way that the photochemistry of iron is studied, the other sensitive metallic compounds may be dealt with. The reduction of uranic salts, and the development of uranium prints by various reagents, will naturally be connected with the analogous ferric salts. The photochemical reduction of chromates in the presence of organic substances, such as gum, albumen, and gelatine, will lead to the numerous practical applications of chromated gelatine in the processes of etching, pigment printing, collotype, etc. In these processes practical instruction may be given at this stage as far as thought desirable. The salts of mercury and copper may also be studied with advantage, as illustrating the nature of photochemical decomposition.

The well-known greenish mercurous iodide is easily prepared by decomposing freshly precipitated and washed mercurous chloride with a solution of potassium iodide. Some of this salt, washed by decantation, and exposed under water to the action of strong light, rapidly darkens, owing to the liberation of metallic mercury. According to H. W. Vogel, the decomposition may be represented by the equation:

$$3\,Hg_2I_2=2\,Hg+Hg_4I_6$$

The compound $Hg_4I_6$ is mercuroso-mercuric iodide, $Hg_2I_2$, $2\,HgI_2$. The decomposition of mercuric chloride in the presence of ammonium oxalate is also an instructive illustration of photochemical decomposition, as it takes place with comparative rapidity, being the reaction made use of in Eder's chemical photometer:

$$2\,HgCl_2+(NH_4)_2\,C_2O_4=Hg_2Cl_2+2\,NH_4Cl+2\,CO_2$$

The action of light on the salts of copper forms a convenient introduction to the photochemistry of the silver salts. Thus cuprous chloride darkens, on exposure to light, with as great a rapidity as silver chloride. It may be pointed out that the nature of the decomposition in this case is not completely understood. Wohler conjectured that the product might be an oxychloride, and this view receives support from the circumstance that cuprous chloride does not darken under hydrocarbon oils or other liquids which do not contain oxygen. A. Vogel assigns a formula, $CuCl_2$, $3\,CuO$, but the subject requires further investigation.*

A general discussion of the subject of photochemical decomposition, as illustrated by the foregoing and other examples, will enable the student of photographic chemistry to grasp the broad idea that modern photographic processes represent only the special applications of wider principles, and that photography with silver compounds may be but a passing phase in the history of the art. In the present state of knowledge, no rigorous classification of the cases of photochemical decomposition is possible, and it is only necessary to point out, and to illustrate by an appeal to some of the many known instances, how difficult it is to draw a hard and fast line between photochemical decomposition and photochemical combination, or between decomposition and dissociation under the influence of light. Many of the supposed cases of dissociation may be dependent on the presence of another substance capable of combining with one or the other of the liberated products, and thus playing the part of a sensitizer in relation to the present subject.

From such considerations as these, it will follow that in all modern photographic processes we have to deal with a mixture of chemical compounds capable of passing into a more stable system under the influence of light as a source of external energy. If the new products formed in this way are so acted upon by reagents subsequently applied that a visible and striking color difference is produced, or if the new product differs in color from the original substance or mixture of substances, we have all the essentials for a photographic method.

When discussing photochemical decomposition it should be pointed that indirect results are often obtained by using a mixture of substances of which one of the constituents is not directly affected by light, but it is altered by contact with the product resulting from the photochemical decomposition of the other constituent of the mixture. For example, paper, coated with ferric chloride, and exposed to light, gives a surface of ferrous chloride by photochemical reduction, the size or cellulose of the paper acting as the sensitizer (chlorine absorbent). But if the surface is coated with a mixture of ferric chloride and cupric chloride, the ferrous chloride which is formed reduces the cupric salt with which it is in contact:

$$2\,FeCl_2+2\,CuCl_2=Cu_2Cl_2+2\,FeCl_3$$

The picture is thus formed in cuprous chloride instead of in ferrous chloride, and, by treatment with potassium thiocyanate, cuprous thiocyanate is formed which, on subsequent treatment with potassium ferri-

* Ausführ. Handb., Part I.; Vogel's Handb. d. Photog., Part I.

† Such films of silver haloids on glass are very convenient for experimental purposes, as they are (when dry) absolutely free from anything that can be regarded as a sensitizer, and are therefore particularly well adapted for purposes where films of the pure haloids are required.

‡ H. W. Vogel has obtained a positive print in thymoquinone by making use of this property. See his "Handbook," Part I., p. 41.

* The addition of some alcohol increases the sensitiveness of the mixture.

* See Dingler's "Poly. Journ.," vol. cxxxvi, p. 238; also Carlemann, in "Journ. fur Prac. Chem.," vol. lxiii, p. 475.

cyanide, leads to the development of a brown print. This method of utilizing a mixture of ferric and cupric salts is the basis of Obernetter's process.

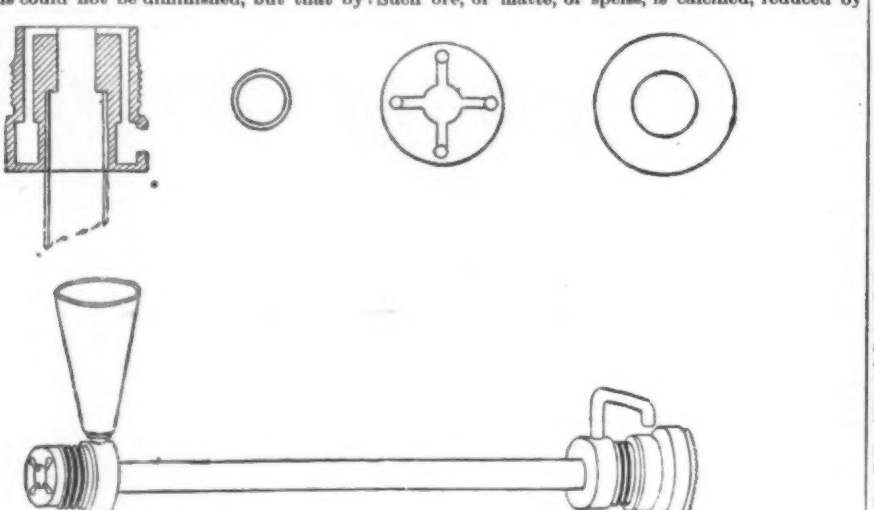
There can be no doubt that this principle of indirect decomposition is destined to play a very important part in the photography of the future. It has already come into prominence in the well-known platinotype process of Willis, in which a surface is coated with a mixture of ferric oxalate and potassium chloroplatinite. On exposure to light ferrous oxalate is formed, while the chloroplatinite is not directly reduced. On treatment with a hot solution of potassium oxalate the ferrous oxalate is dissolved out, and at the moment of solution reduces the chloroplatinite to finely-divided platinum *in situ*. In the direct printing platinotype process we have a surface of potassium chloroplatinite, sodium oxalate, and sodio-ferric oxalate. In this case the reduction of the ferric salt by light is accompanied by the indirect reduction of the chloroplatinite by means of the ferrous salt thus formed. In the cold platinotype of Willis the operations are separated, the ferric surface being first exposed in the usual way, and then development being effected by immersion in a cold solution of potassium chloroplatinite containing potassium oxalate and phosphate.

The discussion and illustration of indirect methods of decomposition, as illustrated by the platinotype processes, may advantageously occupy the student's attention at this stage of his work. The chemistry is comparatively simple, and many experimental illustrations will obviously suggest themselves to the teacher.

## NEW CONTINUOUS TUBE FOR THE RAPID EXAMINATION OF SUGAR SOLUTION IN THE POLARISCOPE.

IN the March number of the *Bulletin de l'Association des Chimistes* H. Pellet publishes an account of a new polarization tube designed for rapid examination of sugar solutions.

Pellet made a study of the time necessary to bore out a sample, weigh, introduce into flask, filter and polarize, and he found that the time for performing the first four operations could not be diminished, but that by



EXAMINATION TUBE FOR SUGAR. (One-half actual size.)

use of a special form of polarization tube, time could be saved in the polarization. The new tube has reduced the time of the last operation to a minimum. The cleaning, filling and adjustment of cover glass to polarization tube takes at least one minute, while with the new tube only a few seconds are taken in filling ready for an observation, and without the tube being removed from the polariscope. With the accompanying figures the construction of the tube needs no description.

The method of using this tube is as follows:

Fill the tube with sugar solution to make reading; immediately, on noting reading, pour the next solution into the funnel, when the fresh liquid will completely displace that already in the tube. The moment all the old solution is displaced is known to observer by the disappearance of all convection current which renders an observation impossible. Pellet found that using polarization tube 400 mm. long, 50–70 c.c. of solution was sufficient to completely displace old liquid.

Before using tube it should be filled with water, and zero point controlled. Make sure that the cover glasses and ends of tubes are tight.

Four readings may be made in a minute, double as many when ordinary form tube is used, and this means 1,200 polarizations in ten hours.—*La. Planter.*

## CHEMISTRY AT THE BRITISH ASSOCIATION.

THE proceedings of Section B at Cardiff, says *Nature*, were not felt to be as interesting as on some previous occasions. Several well known chemists were not present, and no set discussions on subjects of general chemical interest, which have been special features at other times, took place. Still, in the course of the meeting several papers of very considerable importance were read, and provoked valuable comments. The President's address was listened to by an enthusiastic audience, and his remarks, together with several of the papers contributed during the meeting, should give a fresh impetus to the study of the metals.

Prof. Dunstan read the Report of the Committee on the Formation of Haloid Salts. It has been found by Mr. Shenstone that chlorine, prepared by the action of hydrogen chloride on manganese dioxide, attacks mercury readily, even when both substances are pure and dry, while that obtained by heating platinous chloride only attacks mercury extremely slowly. Incidentally it has been discovered that pure platinous chloride is a very difficult substance to prepare, an oxychloride being formed at the same time. The results so far obtained are to be regarded as preliminary.

Prof. Vivian B. Lewes read a paper on the spontaneous ignition of coal. His experiments lead him to reject the explanation of Berzelius, which attributes spontaneous ignition to the oxidation of pyrites contained in the coal. The heat given off by the combustion of the pyrites present in the most dangerous kind of coal, even if localized, would not be sufficient to raise the temperature of the adjacent coal to the ignition point. The cause of spontaneous ignition of coal is to be found, rather, in its power, especially when finely divided, of absorbing oxygen, which causes the slow combustion of some of the hydrocarbon constituents even at the ordinary temperature. The action may increase under favorable conditions until ignition of the coal results. The risk is greatest with large masses of coal, and with the ordinary air supply on board ships. The oxidation increases rapidly with the initial temperature of the coal, so that coal fires are found to occur most often on ships frequenting tropical climates. It may be roughly estimated that the absorbing power of a coal for oxygen is proportional to its power of taking up moisture.

In the discussion which followed, Prof. Bedson mentioned his experiments on the heating of coal dust at various temperatures up to 140° C. He had noticed that in some cases combustible gases were given off by the coal.

A feature of special interest was the exhibition by Ludwig Mond of specimens of nickel carbon oxide and metallic nickel obtained therefrom. In the paper read in conjunction with this exhibit an account was given of the discovery and properties of the above compound. The physical properties have been described in the *Journal für physikalische Chemie*. Chemically, nickel carbonyl is most inactive, numerous experiments made to introduce the carbonyl group into organic substances by its means having been uniformly unsuccessful. Experiments were described having for their object the direct extraction of nickel from its ores by means of carbon monoxide. It was found that, as long as the nickel is combined with arsenic or sulphur, the process is entirely successful on a laboratory scale. Such ore, or matte, or speiss, is calcined, reduced by water gas at 450°, cooled down to a suitable temperature, and treated with carbon monoxide in a suitable apparatus. On exposing a heated surface to the gas containing nickel carbon oxide, it is possible to produce, direct from such gas, articles of solid nickel, or goods plated with nickel, resembling in every way those obtained by galvanic deposition of metals, and reproducing with the same exactitude and fineness any design upon such articles. This result can also be obtained by immersing heated articles in a solution of nickel carbon oxide in such solvents as benzole, petroleum, tar oils, etc., or by applying such solution to the heated articles with a brush or otherwise.

A specimen of iron carbon oxide was exhibited, which Messrs. Mond and Langer have obtained as an amber colored liquid, which, on standing, deposits tabular crystals of a darker color, and solidifies entirely below −21° C. to a mass of needle shaped crystals. It boils at 102° C., but leaves a small quantity of green colored oil behind. Several analyses and vapor density determinations have been made, but it is not yet certain whether a pure substance has been obtained or a mixture of several iron carbonyls. The authors hope shortly to publish a full account of this interesting substance, which differs considerably in its chemical behavior from nickel carbon oxide.

Mr. Crookes described his experiments on the electrical evaporation of metals and alloys. If a brush of gold is placed in a vacuum tube and connected with the negative pole of an induction coil at ordinary temperature, and if a piece of glass be placed underneath the gold in the tube, on passing the current a metallic mirror appears on the glass, increasing in thickness to a leaf, which can be peeled off, and which is perfectly homogeneous. Films of silver and platinum can also be obtained. It is found that different metals thus treated evaporate at different rates, one or two, such as aluminum and magnesium, being apparently non-volatile. It is thus possible, in the case of the aluminum gold alloy discovered by Prof. Roberts-Austen, to separate a large portion of the gold from the aluminum by electrical evaporation.

T. Turner gave an account of experiments which he had made to discover the cause of the red blotches which often appear on the surface of brass sheets on rolling, and which are a great source of annoyance to Birmingham manufacturers. They are due to the erosion of the zinc by the chlorides present in the solution in which the brass has been pickled, and in the water in which it is afterward washed, care not being always taken to prevent such chlorides from drying on before rolling.

A. P. Laurie described the experiments he has made to determine the electromotive forces of various alloys with a view to establishing the existence of definite compounds among them. His earlier experiments will be found in the Journ. Chem. Soc., 1888, p. 104. His recent work leads him to conclude that a compound of gold and tin of the formula AuSn exists, a sudden rise of electromotive force being observed when the proportion of tin in the alloy exceeds that required by the above formula. Compounds do not appear to exist among the alloys of zinc, cadmium, lead, and tin.

Prof. Roberts-Austen exhibited and described his self-recording pyrometer. In this instrument, thermal junctions of platinum and platinum containing 10 per cent. of rhodium are connected with a galvanometer. The spot of light from the mirror of this is caused to fall on a slit before which a photographic plate passes at a given rate, by which means a curve is traced, corresponding to the variations in temperature of the heated thermal junction. The other junction is kept at a constant temperature by immersion in water. Temperatures up to the melting point of platinum can be determined with an accuracy of 10°. The curves of cooling of several alloys have been determined. The alloy of gold and aluminum differs from others, such as that of platinum and lead, in that there is no break in the curve at the point of solidification of the alloy.

A paper by A. Vernon-Harcourt and F. W. Humphery was entitled "The Relation between the Composition of a Double Salt and the Composition and Temperature of the Liquid in which it is formed." The authors have obtained a large number of double chlorides of ammonium and iron by crystallizing from solutions containing varying amounts of ferrous and ammonium chlorides, and maintained at different temperatures. The composition of the salts varied, according to conditions, from two to twenty-one molecules of ammonium chloride combined with one of ferrous chloride. The salts could be obtained well crystallized, and varied considerably from each other in their crystalline habit. The authors suggest that similar complex compounds may exist in other cases.

Prof. Dunstan, in the discussion which followed, described a series of double cyanides of zinc and mercury, of complex composition, which he had obtained by precipitation.

In a preliminary account of some experiments he is making on the action of oxide of cobalt in causing the evolution of oxygen from hypochlorites, Prof. M'Leod showed that, on boiling an alkaline solution of a hypochlorite alone, some oxygen is evolved and chlorate formed, so that the action is probably somewhat complex in presence of oxide of cobalt.

In the absence of Prof. Armstrong, Dr. Morley read the Report on the Isomeric Naphthalene Derivatives. The study of the dichloronaphthalenes has been completed. Of the twelve reported to exist, only ten could be obtained. This number is that required by theory. Of the fourteen theoretically possible trichloronaphthalenes, thirteen have been obtained. The compound containing the chlorine atoms in the positions 1 : 2 : 1' is missing. These results put it beyond question that naphthalene has a symmetrical structure. Its exact inner configuration has yet to be dealt with. Experiments have been made with a view to determine the manner in which substitution takes place. It appears probable that an addition product is always first formed.

Prof. Rucker gave an account of the experiments made by Prof. Roberts-Austen and himself to determine the specific heat of basalt. The experiments were performed with the aid of the self-recording pyrometer above mentioned. The results obtained when the substance was heated in a platinum crucible in a gas furnace agreed well together. The specific heat increases regularly up to the melting point, which is not very definite. About this point there is considerable absorption of latent heat. The mean specific heat between 20° and 470° was found to be 0·199; between 470° and 750°, 0·244; between 750° and 880°, 0·626; and between 880° and 1190°, 0·323.

Prof. F. Clowes described an apparatus for testing safety lamps which permitted economy in the marsh gas used. It consisted essentially of a large wooden box, rendered gas tight by paraffin, in which the mixture of fire damp and air could be made, the safety lamp being afterward introduced. A lamp was exhibited which would indicate in this apparatus 0·25 per cent. of fire damp.

Prof. C. M. Thompson described the results he has obtained on repeating the experiments of Kruss and his colleagues on the rare earths, which caused them to announce the probable existence of about twenty new elements. Although he has worked on material from the same locality and of the same appearance as that used by the above named workers, he has entirely failed to confirm their results, at any rate with regard to the didymium fraction. He considers that the absence of certain lines noticed by them in the didymium spectrum may be due simply to dilution, and do not indicate a splitting up of that element. On making his solutions sufficiently strong, he was able in all cases to obtain the lines.

Prof. Ramsay drew attention to the remarkable properties which are exhibited by the liquids obtained by passing excess of hydrogen sulphide into solutions of certain metals, and afterward expelling the excess of hydrogen sulphide by hydrogen. Mercuric sulphide treated in this way dissolves to a dark brown solution. Antimony and arsenic sulphides also dissolve. On examining the mercury solution under the microscope, brown particles are seen in a state of rapid motion. With antimony solution, particles are not visible, but a sort of granular movement is to be seen. With arsenic solution, nothing is visible. On dialysis of the solution, none of the metal diffuses if the solution is pure; in the case of the antimony, diffusion takes place if tartaric acid is present. These solutions are readily precipitated by the addition of certain salts, but, although the antimony solution becomes nearly solid on precipitation, no accompanying rise of temperature can be noticed. Also, no depression of the freezing point is observed with such a solution. The specific gravity of the solution, however, is higher than that of water. The experiments show the power of the solvent to bring about extremely fine mechanical division of a substance, and suggest the possibility of

further atomic or ionic separation. The particles of quasi-dissolved substance are believed to be in a state of rapid but circumscribed motion.

One of the few papers on organic chemistry was read by J. J. Sudborough, on the action of nitrosyl chloride on unsaturated carbon compounds. He has examined the action of nitrosyl chloride on ethylene, propylene, amylene, and cinnamene, crotonic, oleic, erucic, and cinnamic acids. Of these, ethylene is chlorinated, and forms the dichloride, $C_2H_4Cl_2$; propylene is practically unacted upon; amylene forms a nitrosochloride, $C_5H_{10}NOCl$, melting at 152°; and cinnamene a similar compound, $C_8H_8NOCl$, melting at 97°. Crotonic acid is unacted upon, even when heated to 90°, while oleic and erucic acids readily form definite nitrosochlorides, the former melting at 86° and the latter at 93°. Cinnamic acid is unacted upon when cooled, but forms the dichloride, $C_9H_8O_2Cl_2$, when heated to 100°. Up to the present the author can find no laws regulating the action of nitrosyl chloride on various carbon compounds.

A paper was read by C. G. Moor, on a new method for the disposal of sewage. This consists in the application of a method invented by Mr. Rees Reece for obtaining tar, ammonia, etc., from peat, to the recovery of similar products from sludge cake. A kind of lime kiln is employed, with a force draught, connected to a series of condensers. The operation is conducted in such a manner that the material in the lower part of the furnace is kept in active combustion; its heat distills the material directly above, and this in its turn gradually descends to serve as fuel for the succeeding charge. Eighty per cent. of the theoretical yield of ammonia has been obtained. In order for the process to be commercially successful, it seems that the use of lime in pressing the sludge should be avoided at all costs, as, if much lime is present, the ash obtained in the furnace has a very low value, and clinker is apt to be produced. The author suggests the use of carbonized sludge in powder, mixed with salts of alumina and iron, in place of lime.

A. H. Allen described a curious reaction he had noticed on treating glycerides with alcoholic potash. If the quantity of potash or soda present is insufficient to completely saponify the glyceride, an ethyl salt of the acid is obtained. Thus in the case of butyrin large quantities of ethyl butyrate pass over on distillation. In the case of acetin it was found that no action took place on boiling sodium acetate, acetin, and alcohol together; but, on the addition of a trace of potash, 80 per cent. of the theoretical yield of ethyl acetate was obtained.

## EFFECT OF LIGHT ON GROWTH.

IT has long been known that light is of vital importance to all animal and vegetable organisms, and that everything pertaining to their development and maintenance depends upon its influence.

During many decades experiments have been made upon the plant, but it is within comparatively recent years that the effect of light has been studied with reference to the animal kingdom. Prominent among these latter investigations may be mentioned those recently published in Germany, together with the researches of Dr. Martin, of the Johns Hopkins University, Baltimore.

In studying the influence of light upon vegetation, it should be borne in mind that the vegetable world is the great medium between the mineral and the animal kingdoms. Through its agency the inorganic materials are taken up and assimilated, thus becoming suitable for the nourishment of the animal body. The latter cannot exist without the former, and whatever affects the one must of necessity have an indirect influence over the other.

On the bare surface of the wind-beaten cliff the mysterious lichen finds a sufficient amount of those elements which assimilate, and form its structure, to support it through all the stages of its growth; and at last, having lived its season, it perishes, and in its decay forms a soil for plants that stand a little higher in the scale of vegetable life. These again have their periods of growth, of maturity, and of dissolution, and by their disintegration they form a soil for others, which pass through the same channel, until at length the once barren waste is covered with an abundant vegetation.

In a short time we find the almost microscopic seed placed in a few grains of earth, springing into life, developing its branches, unfolding its leaves, and producing flowers and fruit. Although it has become a full grown plant, there is but little diminution of the soil from which it grew, and from which it would appear to have derived all those solid matters of which its structure is composed.

Careful experiments have shown that a small amount only of the soluble constituents are taken up by the roots of the plant. We must therefore look to other sources for the origin of the woody matter, of the acid and saccharine juices yielded by the vegetable world. These are all, it will be found, formed by some mysterious modifications of a few elementary bodies. The plant, in virtue of its "*vitality*," and under the excitement of the solar rays, effects the assimilation of these elements; and this is the phenomenon which it is the province of this article to examine.

Through the correlation of energy the most superficial student of philosophy can trace all force, and, consequently, all organic life, to the influence of the sun. The winds that blow and the rains that fall are among the most obvious results that may be traced to the influence of this omnipotent power, but this brings us merely to the threshold of our subject.

Although it is only by means of light that the plant can *prepare* materials for its growth from inorganic matter, yet if an adequate amount of assimilated substance has been *stored up* as potential energy, growth can go on in the dark until this store is exhausted, and if then dried the plant will weigh no more than its original germ. Such an example is seen in the ordinary seed. This little embryonic body is planted and sprouts, but its latent energy soon becomes exhausted, and if sunlight is then denied it, it must necessarily perish. It may therefore seem paradoxical to state that nearly all vegetable growth takes place in the dark, but, nevertheless, such is the case. Direct sunlight tends to retard both growth and germination; thus we see the growing tissues protected by external structures, and the seeds placed under the soil.

It is not yet positively known whether light has any direct effect upon the respiration of the plant; in some experiments there has been a slight increase, in others a diminution of the rate with increased illumination, but it is not certain that all other factors were excluded.

In 1771 Priestley tried the experiment of placing a candle in a confined space until it burnt itself out; then placed the green parts of a plant in the inclosure, and at the end of ten days the air had become sufficiently pure to permit the relighting of the candle, thus proving that plants have the property of giving oxygen to the surrounding atmosphere; but he also observed that at times the reverse phenomenon seemed to result, which was not explained until ten years later, when Ingenhousz continued the experiments. To use his own words: "I had just begun these experiments when a most interesting scene revealed itself to my eyes. I observed that not only do plants have the power of clearing impure air in six days or longer, as Priestley's experiments seemed to point out, but they discharge this important duty in a few hours, and in the most thorough way; that this singular operation is not due at all to the vegetation, but to the effects of sunlight; that it does not begin until the sun has been some time above the horizon; that it ceases entirely during the darkness of night; that plants shaded by high buildings, or by other plants, do not complete this function, that is, they do not purify the air, but, on the contrary, they exhale an injurious atmosphere into the room about us; that the production of pure air begins to diminish with the decline of day, and ceases completely at sunset; that all plants corrupt the surrounding air during the night, and not all portions of the plant take part in the purification of the air, but only the leaves and green branches."

Senebier, in furthering the discoveries of Lavoisier, affirmed that the air absorbed and decomposed in the daytime by plants is nothing more than carbon dioxide, and that the pure air resulting from the decomposition is oxygen. This theory, however, may be questioned. The disappearance of carbonic acid and the appearance of oxygen does not necessarily prove that carbonic acid is decomposed into its separate constituents, as the absorption of the acid, together with water, would give the same result, the latter furnishing the oxygen for the purification of the air. In favor of this view it may be stated that water is much easier decomposed than carbonic acid. Indeed, so great is the chemical affinity between carbon and oxygen, that the atoms of carbon will take the oxygen from water, and free the hydrogen, and continue doing so *until the valence is* satisfied. In the formation of starch $n\,(C_6H_{10}O_5)$, carbonic acid and water come directly together in the economy of the plant, and the superfluous oxygen from the water is liberated, as will be explained by the following formula: $6\,(CO_2) + 5\,(H_2O) = C_6H_{10}O_5 + 6\,O_2$.

The early investigators were unfolding a great truth, but they were of necessity working largely in the dark, as the so-called organic chemistry of to-day was to them an unraveled enigma. In just what way the carbon of the atmosphere becomes transformed into the organic compounds is open to question, as has already been intimated. It may be stated, however, that the supposition of earlier days, that the foliage was the only agent through which this metamorphosis was accomplished, is on erroneous one.

In support of this assertion it can be said that the sap of plants is stronger near the ground months before the leaves appear; it is also rich in organic compounds, as is seen in the sugar maple and sugar cane. There are also many active organic compounds in the roots that never appear in the leaves. That the roots, therefore, as well as the leaves of the plant, play an important part in the absorption of the carbonaceous matter, which is eventually transformed and assimilated in the vegetable economy, is now well authenticated. Dr. Sharp, of Baltimore, has recently undertaken some interesting experiments confirming this view. He has planted grain in a stiff clay soil devoid of carbonic acid, and no sign of growth resulted. Upon mixing the same clay with carbonaceous matter, however, the growth started at once. He has never been successful in killing the plant by cutting off all the leaves, but has caused death by removing a certain number of roots. At one time two separate fields were planted with wheat, one of which was heavily charged with carbon. The growth in this field was wonderful, whereas the wheat planted in the common soil was far less vigorous and complete. This is the principle that leads to the use of fertilizers. It is not an uncommon thing to see leaves, dried and withered during a hot day in summer, swell up and grow quite appreciably before sunrise, although the assimilation by means of the leaves has been inactive during the period of darkness.

It would be hard to say which were the better servants of the plant, the leaves or the roots, but that the latter play a very important part in furnishing substantial nutriment, as well as moisture, there can no longer be any reasonable doubt. It may be further stated that the human body contains, in addition to its organic constituents: calcium, chlorine, fluorine, iron, magnesium, phosphorus, potassium, silica, sodium, and sulphur, the majority of which originally came from the vegetable kingdom, and which the plant could not have derived from the air.

The respiration of the plant can take place in the darkness as well as in the light, and results in the absorption of oxygen and the freeing of carbonic acid; in this respect it resembles the animal kingdom.

It is in the *assimilation* of the vegetable, *i. e.*, the process by which new tissue is formed, that oxygen is set free, and in this case carbonic acid is absorbed. As this operation requires light, so far, at least, as the foliage is its agent, it is readily understood why plants corrupt the atmosphere during the night. The table placed below will show the chief difference between the respiration and the assimilation of the plant.

| Assimilation. | Respiration. |
|---|---|
| Requires light. | Can proceed in darkness. |
| Carbonic acid ($CO_2$) absorbed. | Oxygen absorbed. |
| Plant gains in dry weight. | Plant loses dry weight. |

Each color of the spectrum possesses a distinct function toward the development of plant life, and indeed may be said to have a specific quantitative influence upon assimilation.

It would be well to say a few words in reference to the colors of the spectrum before speaking of their individual effect upon plant development. They are classed in two great divisions, the califoric and the actinic. The green, blue, and yellow rays belong both to the califoric and the actinic classes, while red is purely a *califoric* and violet an actinic ray. In the study of biology this knowledge is made of practical importance in the production of the photo-micrograph. The light, which is eventually to be spread over a comparatively large surface, must be concentrated upon a bacterium entirely invisible to the naked eye.

It is obvious that when the germ is placed under a burning glass sufficiently powerful to illuminate it for reproduction on the negative, it would immediately be burnt beyond all recognition, were it not for the fact that the heat rays are excluded, and only the light of a purely chemical or actinic nature used for illumination.

Seeds placed in the red light can rarely be made to develop signs of germination, and the same light operates to check the growth of plants, probably owing to the fact that this color does not produce a perceptible decomposition of carbonic acid gas.

In 1844 Dr. Draper discovered that the rays which cause the decomposition of carbonic acid, or, to be more exact, the assimilation of the acid, have the same place in the spectrum as the orange, the yellow and the green, the blue indigo and violet exerting no perceptible effect. Thus we find that the chemical rays exert little influence upon assimilation; they hasten the process of germination, however, so that seeds will sprout in less than half the time required in darkness, and one third the time required in ordinary light.

Strange though it may seem, these colors of light will penetrate the earth and act upon seeds buried more than an inch below the surface of the soil. Under the influence of the actinic rays the embryonic plant seems to be unduly excited, much as we have seen a mouse when under a glass jar filled with oxygen gas.

The green and yellow lights produce the greatest effect upon plant development, and, in consequence, we find that while seeds will sprout and send out roots without these rays, they will develop no healthy leaves nor strong woody fiber. This is readily understood when we find that only the orange, yellow and green rays of the spectrum promote the assimilation of carbonic acid, and in this process the yellow ray is as efficient as all the others taken together, while the most refrangible rays, those which act most energetically upon chloride of silver, have only a very slight influence upon the work of assimilation.

In the combustion of carbonaceous material the flame presents those colors which were originally required to effect the transformation from the inorganic world, and it is for this reason that we see the orange and yellow colors prevailing.

Plants will grow well in light deprived of its orange and red colors, but they will rarely make any attempt to blossom, and without the red their fruits will not ripen. Common mushrooms are the only known exception to the principles here related. These fungi cannot be made to germinate nor grow under any color except yellow, and it is apparently at the time when that color is greatest in sunlight that they are found in greatest abundance. It may here be suggested that the blue and violet rays are not required, owing to the fact that the metamorphoses attending germination do not take place in the same manner as in the green plants. These fungi may grow in darkness, which at first seems contrary to the principles of plant development, but it should be remembered that they assimilate organic matter, and consequently receive energy in an indirect manner.

Sir John Herschel, Dr. Draper, Robert Hunt, and many others, have studied these phenomena of light, and have shown that, from seed time to harvest, the plant life requires in succession the colors in the same order as in the spectrum—from violet to red—and they have also shown that this want is actually supplied. In the spring sunlight is found to contain the violet and blue rays in abnormal amounts; as the season advances, each color in turn increases in intensity, and in the autumn we have an excess of red; to this excess the turning of autumn leaves is partially due. Dr. Draper has gone further still, and has found that these effects vary with the latitude, so that in high latitudes this constant stimulus to growth is greatest where it is most needed, owing to the shortness of the season.

It is well known that plants placed near the window turn the faces of their leaves to the light, and this will be more noticeable if there are a few blue panes, but make them red and the plant will turn its face away as if in disgust. The rule is almost universal, in the northern hemisphere, that the twisting grain of the tree and the tendril indicates that with each day's growth it had tried to follow the sun in its course, causing a twist from left to right.

Numerous observers have investigated the influence of the electric light upon assimilation. In one instance, at the "Palais de l'Industrie," in Paris, it was found that the total assimilation produced in leaves of certain plants, during an exposure of five days, was not equal to that which followed exposure to sunlight for a single hour. It was even found in some cases that the electric light produced injurious effects.

The observation of plants has taught us much, but the effect of light upon the animal being less direct, and circumstances for experiment less favorable than in the vegetable world, but little attention has been given to the study of this phase of the question. Only one of the senses—that of sight—depends directly upon light for the maintenance of its function. It is not until deprived of the sun's rays that blindness begins to approach, and ultimately becomes complete, as may be seen in the fishes inhabiting caves.

In those occupations where men are obliged to remain underground during the daytime, the pallor of the complexion is not only due to a lack of the tan pigment, but is also encouraged, to a greater or less extent, by an anæmic condition of the system, *i. e.*, where the oxygen-carrying power of the blood is not up to the normal standard. As a result we find people so situated especially susceptible to those diseases more or less dependent on this condition.

The germs of disease are variously affected when exposed to daylight, certain kinds being unduly stimulated and infused with renewed vigor, while on others, as is the case with the bacilli of tuberculosis, its action is of a decidedly deleterious nature.

The entire animal kingdom requires and takes from the atmosphere its oxygen for support. It is this which maintains the spark of life, and the product of this combustion is carbonic acid, which is thrown off as a waste material, and which deteriorates the air. The vegetable kingdom, however, *drinks* this noxious air, and in the process of assimilation appropriates the carbon and liberates the oxygen to perform its services to the animal world. It has been claimed by some that the animal and vegetable kingdoms are mutually dependent, and that the existence of the one ceases when the other is destroyed. A little study should convince us that this is an error. It is only during life that external resistances are successfully overcome, and the normal organic structure maintained. As soon as life becomes extinct—both in the animal and in the vegetable—the process of disintegration begins, and nature reclaims all the elements which have but temporarily been loaned to the organic world. Thus we have a balance—on the one side life and growth, on the other disintegration and death—and the two must be equal to one another.

The growth of plants involves the operation of dynamic forces. Through the conservation of energy these forces are retained in a latent form until the elements are returned to their original conditions, either through the action of fire or the process of decay. The heat and colors then evolved must of necessity be equal in amount to that which has been received. It is possible that some portion of the inferior heat of the earth may aid in developing the fiber of the plant, and if so, this amount must be subtracted from the total to obtain the residue of energy received from the sun.

As a general principle, however, it may be stated that all the forces required to convert inorganic matter into the organism of plants must come from the sun in the form of light. The principle also becomes general in its application to animal life through consumption of vegetable growth, to the powers of steam developed from fuel, to the winds and rains, and the lightning's blast, caused by the action of heat rays, and thus to all the forces which man is enabled to turn to his own account in the great problems of his existence, development, and civilization.

GEORGE SEELEY SMITH, B.S.

## OLD AND NEW PHYSIC.

### OLD PHYSIC.

IT would require many numbers of the *Asclepiad* to describe the changes in forms of practice that have taken place in the past five decades. The aged men even of my first days in physic would not know what to make of the physic of this time. I remember, in the clearest manner, a practitioner of the good old type in my boy days. I often lived in his house, and the first operation over which I stood trembling was neatly and expeditiously performed by him, in the extraction of a molar tooth with an instrument—by no means so bad an instrument as it has been accredited, by the way—called the key. He was a gentleman every inch of him, in education, in courtesy, in dress, in manner. His dress was singularly becoming; it was the dress which in his early life was ordinary in the professions, but fast dying out. It is still seen, in part, in the dress of the sergeant-at-law, and perverted and vulgarized in some ecclesiastical costumes. The coat, of dark cloth, was single breasted, fitted neatly to the body, and coming well round the chest was cut away something like a modern dress coat, but without the absurd right angles which separate the body of the modern garment from the tails. The waistcoat, of black silk, was rather long, the pockets of good size, with nicely cut flaps, and with an open front, from which issued a fine cambric frilled shirt front, surmounted by a white neckerchief. The nether garments were dark knee breeches of good fit, with what a Glasgow student, who afterward stumbled into a baronetcy, was accustomed facetiously to describe as "the rummy fall down with the artful dodge at the knee;" but, nevertheless, they suited well. On special occasions of ceremony the breeches were continued by black silk stockings, with light shoes, nicely fitting, mounted with broad silver buckles; but on ordinary occasions they were finished off with black gaiters and heavier shoes, and for riding with long boots of black leather which extended up to the knee. To complete the outdoor costume, a low and rather broad brimmed hat covered a head the hair of which, curled in front, was neatly brushed back. Taken altogether the dress was in excellent taste; it gave to its wearer a distinguished appearance, subdued when compared with the bewigged and fuller costume of a still earlier time, yet contrasting strongly with the any sort costume of to-day. The dress was not peculiar to the doctor; it was what was called the habit of the gentleman of the period; and only marked the gentleman of the medical faculty when he carried with it the gold headed cane, a cane containing a hollow box at its top, perforated like a pepper box, from which its owner could breathe into his nostrils the odors of camphor or other supposed antiseptic substance, during his attendance on the infected sick; for in those days Dwight's animalcular or vital theory of contagion, the germ theory of our time, was still in force.

In his method of treating the sick, the practitioner of the old school had a lively sense of the value of medicines and of remedial substances generally. He cared little or nothing about hygiene. He let his nurses draw down the blinds of the windows of the sick room, and make it a dark and dirty dungeon, without the slightest compunction. He did not object if the excretions from the patients were left in the utensils under or near the bed for hours at a time. He had no love for open windows; and, unless the weather were very cold, he never troubled about the fire or the external temperature; but he enforced freedom from noise, and secured mental repose by directing the street below to be covered with straw. He ordered low diet in acute cases; and, as a rule, he knocked off stimulants so rigorously that his permission to administer a glass of wine, or beer, was looked upon by the joyful family as a first and certain sign of recovery, a practice out of which Dr. Cheyne, of Dublin, made fine satire. He never for a moment forgot his potent remedies. The lancet, the cupping glass, the leech, the calomel pill and black draught, the effervescing mixture to be taken every three or four hours, the sleeping draught, the cooling lotion to be applied to the head, the blister and the blister ointment followed by the "tonic" day after day "during convalescence"—these were almost inseparables from his routine. What in my young days I myself have had to dispense, in this fashion, perhaps for one unfortunate man or woman, is too sad to remember too faithfully. We had our medicine boy, who took out the physic in a basket with two lids opening from the center. One half would take about "six lots," and one small boy would deliver both halves—a good load—in one round, while in busy times we would press the postman into our service, to relieve the boy or boys.

Say what we may of him now, the doctor of the old school was right loyal to his remedies. He had at his command fearful means, and he stuck to them. They were not many nor much varied, but such as they were there was no mistake about them. Tartar emetic in sixth of a grain dose until it was "tolerated;" mercury until it "touched the gums;" half an ounce or even an ounce of Epsom salts; effervescing tartrate of potash or soda mixture *ad libitum;* bark up to cinchonism; and occasionally a bolus!

But the great remedy was blood letting: every man carried a lancet; and a tortoise shell lancet case holding two bright blades was considered the most befitting present for a youth about to be articled. Mine I keep still as a *souvenir*. It was a joke to direct a youth to learn to practice venesection on what were called "the veins of a cabbage leaf;" and some, thinking it proper advice, did in their innocence, begin in that style. The lancet, in frequent use, was supplemented by the leech and the cupping glass. It may seem incredible, but it is the fact, that I knew of one practice in which the leech bill alone reached the sum of one hundred and fifty pounds a year. I also knew a practice in which a man, who had learned to apply leeches skillfully, was attached to the firm as the regular "leechman." He, dear old fellow! was too good and devoted to his work ever to be forgotten; he could make leeches bite when no one else could, "they loved him so;" he was known to fame the country round, and many a countryman was ready to swear that he owed his life to "Old Josh," the "leechman." As to cupping, that was an art of itself, practiced by the professed cupper. I remember a firm of cuppers, father and son, in London, who lived and saved money by their art. One of them, when I was working on the subject of the coagulation of the blood, allowed me to fit up the glass cups he used with slides inside them charged with acids in order to fix the ammonia which might be given off from the blood in vapor. This was Mr. Betts; he rendered me efficient as well as kindly service.

There is no wonder that, in the treatment of acute disease, medicine was not eminently successful in the old days. The wonder is rather that patients recovered so well as they did. Dr. Robert Willis told me that the famous Dr. Gregory, when piling on the "heroic treatment," would say to his students, "Don't be alarmed, gentlemen; it takes a great deal to kill a man." Gregory was right, and if some were not really killed, it was more by good luck than by good management. It was not successful treatment, as all who have lived to compare it with our reformed treatment admit. It was bad at the time, for it left many bad after effects, and it was far worse than no treatment at all of a medicinal kind, a fact the discovery of which every honest observer must in justice accord to the schismatic School of Homœopathy.

The heoric treatment was in swing for nearly a century; and although John Brown and his disciples gave it a check which might have been its death blow if he had been as sober as Hahnemann, it continued after him over half a century, and then died hard.

He would be both a bold and mistaken man who would defend the old school of physic in the ways it followed, as above faithfully described, and yet in many other ways it carried itself in admirable form. It cultivated surgery to perfection, and anticipated, in the most practical manner, the treatment now pursued of closing wounds so as to exclude air. Belloste of Paris, in his essay on the cure of wounds by exclusion of air, revived the old mediæval practice of wrapping up every "green wound" in friar's balsam and leaving the dressing untouched for fourteen days, and he had many followers. Mr. John White, surgeon to the Dowlais Iron Works, treated all his surgical cases, including the severest wounds and compound fractures, in this way, in combination with apposition of parts and perfect rest; and in the domestic school where I learned "the rudimans" the same mode of treating wounds was always followed, and has never been departed from in my own practice, except when I added to friar's balsam a styptic, tannin, and made it more protective by collodion, in the form of styptic colloid.

The men of the old school learned well and perfected the rules of obstetric art until they made themselves masters of it. They cultivated botany with devotion and made it a science; they cultivated natural history and laid the foundations of our modern systems of geology, zoology, and microscopy; they sustained and improved anatomy; they invented chemistry in most of its great departments; they first used galvanic and voltaic electricity; they classified diseases in proper order and nosology; they presented us with the stethoscope for diagnosis; they founded forensic medicine and medical jurisprudence; they began to work at anæsthesia; they kept alive classical and scholarly medicine, leaving Adams and Greenhill as the last splendid specimens of their erudition; and a few of them, like Short, Pringle, Marx, and Tardieu, were early fathers of the modern hygiene. It was only by heroic treatment—in certain details of which, especially in the matter of blood letting, there was after all some good—that they fell. No! there was one fall more. Seduced by the enthusiasm of a handsome, noble and clever woman, they committed the consummate error of trying to wipe out one of the great plagues of mankind by inoculating healthy people with its virus and transforming it systematically from an endemic or sporadic evil into such an epidemic and universal manifestation that almost every human dwelling became its nursery and nesting place.

### NEW PHYSIC.

The contrast between new and old physic in matter of practice is striking. We perpetuate few of the old errors, but we invent new ones for ourselves; we retain many of the old virtues, and we improve or add some by which the signs of such progress as we have made are indicated. In therapeutics the change is phenomenal. Our fathers followed Galen in the view that every practitioner ought to hold all his remedies in his own hand and dispense them himself; the chemist and druggist was the demon. Now it is considered too commonplace for the doctor to dispense his own remedies, and when he does so it is as a sort of favor or necessity—something thrown in, to form, incidentally, or not at all, an addition to the fees for attendance. The doctor's boy with the two-lidded basket is becoming as defunct as the doctor's bill with the red-inked money columns on long sheets of bill paper. The art and mystery of the apothecary has passed over to the pharmaceutist, who pockets the art and kicks out the mystery. This modifies our prescribing altogether. The pharmaceutist pushes his trade industriously to meet our wants, and our wants are many. He grows bolder; he invents for us in advance of our needs. He floods our breakfast tables with his nostrums, advices, and temptations. He is a professor of materia medica, pharmacology, hygienics, diet and regimen, all rolled into one. He has a new remedy for every day in the year, with two for holy days, so that any remedy that lives for a year has a long life. To the one grand narcotic of the old school, opium, so trustworthy, so obedient, so safe, when correctly mastered, there are now a hundred rivals, and not one its equal. The result is that a large section of practitioners is flying after everything, trying everything, and holding fast by nothing; while another smaller section is giving up everything, or, in state of greatest activity, is playing placebo with considerable luck in the play, to their own astonishment. As with medicaments, so with practices. In the good old days of physic the great men were universalists, and the best universalist was the most approved as being deep in his knowledge and as bearing the true title to confidence and commendation. Let a man show a taint of specialism and down he went. "All a specialist, half a quack," was a saying of the late Sir Benjamin Brodie, which represented thoroughly the transitional views of his time. But for several years past specialism has taken such hold on the public mind that perforce the universalists have been almost driven to haul down their colors. The profession is now like a Japanese box, one box within another for any number of boxes—the largest and outer one the general practitioner, who, although he covers the whole, is often carefully set aside by the sick person, in favor of a more restricted one within. Some particular persons seem to have as many specialists as they have organs. I know a lady who boasts of her eye doctor, ear doctor, chest doctor, heart doctor, brain doctor, nose doctor, and womb doctor, as well as what she calls her "general prac."; and of all of them she speaks as if they were men of different professions, just as she might speak of her watchmaker, her bellows maker, or her undertaker. If she could only whip out her eye, or her ear, or her heart, and send it to the right man to be repaired, she would do it in a minute. She goes to him herself simply because she can't help it. Some of these particularly acute persons run specialism finer still. One of them carries a "hussif list" of doctors, in which she has written out for her friends, as well as for herself and family, what every man "is clever for" down to a nicety. I got a look at the list, and found my good friend Dr. A. booked as "very clever for the upper part of the apex of the right lung," and Dr. B. for the "lower part of the upper intestine and the neck of the gall bladder." The utter idiocy of this kind of thing is at last causing a reaction toward universalism by the best minds; but it will take a long time for the great river of medicine, subdivided now into so many little streams, to get back again into its once noble course sailing with the ages. Perhaps the best way will be to follow the example of one of the ablest brothers among us, and become a specialist in everything; universal specialist, holding a new degree—Dr. Omnium Specialorum.

Whatever sound basis there is for specialism is mechanical, and in medicine there probably will always be a special demand for those who are most skillful with their hands and most delicate in the use of instruments. But in the old days, when specialism was at a discount, there was no lack of excellent surgeons, of men who, in much more trying times and scenes than ours, were ready for every operation that science approved, and for every emergency; a fact showing that fashion, together with an insane tendency to specialize everything and everybody, now rules, rather than pure necessity. To this point in medicine we have at last descended, and having got to the bottom without finding the truth we expected to find, we are, we may hope, groping back again toward the light.

### NEW AND OLD ETIQUETTE.

"Old etiquette and new fashion" would have been another appropriate heading to this section of the present paper, for what old physic would have pronounced etiquette is now mere common outdoor courtesy. In the old days there were distinct classes of practitioners—general practitioners and consultants, the consultants being Fellows of one or other of the Royal Colleges of Physicians or Surgeons. To some extent this rule continues, but in a vastly modified and perhaps better form. Grade has pretty well gone out. The "Fellow of the College" in the past was the consultant in the strictest sense. In consultation he was like the lovely rose of Waller's song, he suffered himself to be admired, but he never put himself forward for admiration. The general practitioner took his patient to the great man, held a *bona-fide tete-a-tete* with the most studied ceremony, and all was over. With less ceremony the same may take place still; but in this day patients, without a word to their regular attendants, rush to the consultant, or, as they say in the flattery of their words, to the "fountain head" direct, and the fountain head will now receive them—it is as awful as it is true—alone. Sometimes a patient will go round to five or six fountain heads on the same morning, without telling any one of them that he has already gamboled under another; and having got home with a prescription from each of the heads, wil'

be guided by the opinion of his regular adviser, the chemist and druggist round the corner, as to the prescription most likely to do him good. Sometimes the physician will worm it out of a patient that said patient is under the care of another practitioner, and will write a note to the practitioner about the case. This, which is *en regle* according to the old severe etiquette, is now likely to cause lively offense, however delicately it may be done, both to the patient and the practitioner. In the old time in writing a prescription the physician wrote it and signed it with his initials; the surgeon signed with his name in full; the general practitioner received the document without signing it. Now all sign it, usually with initials only, and any one of them may actually write it. In the old time it was strictest rule that in entering the sick room the practitioner in attendance should lead the way, and the consultant follow, but that on leaving the room the consultant should go out first, and the practitioner in charge follow. This rule was so absolute it became automatic, and a few years ago I should have felt it quite a serious matter to witness a breach of it. In modern physic the rule, still a good one, is, like other rules, out of ordinary consideration. I notice that young practitioners, who have only passed through hospital training, do not recognize it in the least; but, as in ordinary society, invite the consultant as a senior or a stranger to lead the way throughout.

In brief we have strayed from history, from systems of grades, from severe etiquette. We have revolutionized therapeutics, and lifted away many evils, without however substituting much that is, as yet, so demonstrably scientific as to admit of systematic repetition with assured results. We have become animal engineers, and have found that to put foreign elements into our engine is not such good science for keeping the engine in working order, or for preventing it from falling into decay, as prescribing pure air, pure water, pure food, proper rest, and proper exercise. In these directions new physic contrasts favorably with old; and in them is its work for the future, if it is to retain its place in a wiser world.—*Dr. B. W. Richardson, in The Asclepiad.*

## EXERCISE FOR ELDERLY PEOPLE.

By FERNAND LAGRANGE.*

THE tissues and organs do not all mature at once in man. It results that when we reach mature age our capacity for some exercises has notably diminished, while for others it has preserved its complete integrity. At forty-five years the bones and muscles have lost none of their solidity and vigor. The aptitude for exercises of force and bottom continues. But we cannot conclude from this that a man is as apt in all forms of exercise as he was at twenty-five. While the motor apparatus proper is not sensibly modified in the maturity of life, particularly if one has kept it up by regular practice, this is not the case with some other apparatus that begin to decline earlier—notably with that for the circulation of the blood. The heart and the arteries, in spite of the most rational exercises, lose with age a part of their serviceableness, because they lose some of their normal structure.

After thirty-five years of age we recognize, even in conditions of perfect health, a tendency to sclerosis, a defect in nutrition that lessens the suppleness of the vessels and causes them to lose a part of their elastic force. This change, which goes on with increasing age, has received the picturesque designation of the "rust of life." Rust in a machine is the result of a lack of work, while deterioration of the blood vessels is connected with the working itself of the human machine; it is the result of the wearing out of its most essential wheel work, and it is to be observed most prominently in men who have carried exercise or work to the point of abuse. All directions for exercise in mature age, all precautions to be taken in its application, are controlled by this great physiological fact of the lessened capacity of the vessels to support violent shocks. This imperfection of the arterial system is the cause of a considerable tendency to shortness of breath; and it is by this shortness of breath that the man's diminished capacity for resistance is shown.

The differences in the structure of the arteries, even though they may not be carried so far as to denote disease, make the man of fifty years much more vulnerable than the young man; and vulnerable in precisely the organ most essential to life. It is, in fact, the heart that suffers in case of forced exertion, the consequences of a deficient elasticity of the arteries. Every beating of the heart represents the piston stroke of a force pump, and the blood vessels are the pipes through which the liquid flows to carry life to the furthest molecules of our body. But these vessels are not inert conductors; they are endowed, in a healthy condition, with an elasticity which permits them to react at each pulse of the heart, swelling under the pressure of the sanguineous wave, and then contracting and returning to the liquid the impulse which they have received from it. The liquid, striking upon the wall of a fully elastic artery, does not suffer at once the arrest which it would suffer on meeting a rigid wall. A billiard ball, driven against a very elastic cushion, rebounds with nearly as much force as it had when it started. An artery which has lost its elasticity is, as to the column of blood that comes against it, as an ivory ball to a cushion that does not spring. And as the billiard player must strike more vigorously upon the ball to make it perform its run when the cushions do not spring, so the heart, when the artery has lost its elasticity, must exaggerate its effort at the systole to enable every molecule of blood to traverse the circle of the vessels and return to its point of departure. In short, the less elastic the arteries, the greater the effort the heart has to make to secure equal work. Each heart beat, then, of a man whose arteries have become old, is the occasion for an excess of labor by the cardiac muscle. The increase in expenditure of force passes unnoticed if the beatings retain their normal slowness, but becomes very sensible when they are quickened. There are some exercises which cause the number of heart beats to double in a few moments. The resultant fatigue of the organ, which has already been brought to the point of overwork by the continual excess of work it has had to do, is easy to conceive.

The most natural consequence of fatigue of the heart is a momentary diminution of its energy; and when the organ is weakened, the impulse it gives to the blood is no longer sufficient to cause it to traverse as rapidly as it ought the vessels through which it circulates with most difficulty, either on account of their narrowness or of the mass which is precipitated into them at once. Hence what are called passive congestions of the internal organs, and particularly of the lungs. Congestion of the lungs is a frequent consequence in elderly men of exercises which accelerate to excess the rhythm of the pulse, and is shown by shortness of breath. This, which is more prompt in men habituated to physical exercises, is one of the first symptoms of arterial deterioration. It is a warning which it would be a grave imprudence not to heed.

The elderly man should therefore give up all exercises of speed like running, and all those in which energetic efforts are added to speed, like rowing in matches. We see men of exceptional powers of resistance continuing to practice exercises of speed till they are forty-five years old; but it is well to know how indulgence in championship feats late in life usually ends. Many affections of the heart are consequences of exercises or labors that exaggerate the effort of that organ in men who have reached maturity. The central organ of the circulation cannot be subjected without danger to excessive work, when its play is not seconded by the elastic force of an unimpaired arterial system; when it is partly deprived of the re-enforcement which is lent it by these contractile channels, the office of which in the circulation of the blood has been happily described by giving them as a whole the name of the "peripheric heart."

All men who employ animals in work know how their speed falls off with increasing age. Race horses are withdrawn from the track shortly after they have arrived at the full possession of their force; they are still good for competition in bottom, and are capable for many years yet of doing excellent trotting service, but they cannot run in trials of speed. Man's capacity to run likewise decreases after he has passed thirty years; and the professional couriers who are still seen in Tunis, running over large distances in an incredibly short time, are obliged to retire while still young. Those who continue to run after they are forty years old all finally succumb with grave heart affections.

There are some persons who preserve to a relatively advanced age the faculty of enduring violent exercises and of contesting with young persons in quickness of muscular work. Not long ago two men, one forty-five and the other forty-eight years old, contested in the regattas on the Seine and Marne. Their craft was called the old men's. Few oarsmen continue to row in races after they are thirty-five years old. But those whom we are speaking of, though long past the usual age for retiring, have often gained the prizes which competitors twenty years old disputed for with them. These exceptions, however, do not depreciate the force of the principles we have just explained. They prove that one may be young in spite of his years, and that the chronological age does not always agree with the physiological age. While some persons are in full organic decadence at thirty-five years, some others may not yet, at fifty years, have undergone the modifications of nutrition which are the beginning of old age. The capacity of a man for violent exercises is determined by the more or less complete integrity of the arterial tissues. Men who preserve a degree of immunity for exhausting exercises longer than the average are those whose circulation has remained regular, and whose arteries have not yet begun to undergo sclerotic degeneration. They are really younger than their age. Every man, according to the happy expression of Cazalis, is "of the age of his arteries," and not of that which he deduces from his birth. Taking a mean, we may say that after forty years a man ought to abstain from exercises that induce shortness of breath. Instead of exercises of speed, he should adopt those requiring bottom, for which he will preserve a remarkable capacity. Race horses which have become incapable of enduring labor that involves speed may for many years afterward perform excellent service at more moderate paces; they may even easily endure the paces of the hunt, when they have to carry their rider for the whole day, but in which the fundamental gait is not the gallop but the trot. So man preserves to the extreme limits of mature age the faculty of enduring a considerable labor for many hours, provided it is carried on with moderation. Many of the best mountain guides are approaching their sixties, and can easily tire young tourists. But everybody has remarked that the most experienced guides—that is, the oldest ones—go up very slowly, and that under that condition they can walk for an indefinite time. They do this by avoiding, through the moderation of their pace, the quickening of their pulse and the imposition of an excess of work on their heart.

In 1870, when the dangers of the invasion called all French citizens to take part, each one according to his ability, in the defense of the country, national guards of the reserve were organized everywhere, in which all of those who for any reason had not been incorporated in the active service were enrolled. In the exercises of these improvised battalions, men of very unequal ages could be seen elbowing one another in the ranks. Many of them, who had passed their fortieth year, but felt themselves still "game," came to take part in the maneuvers, and were never behind in the long drill marches. Generally, indeed, the elderly men displayed a greater power of resistance than the younger ones. But their superiority vanished as soon as the maneuvers took the form of quick movements. The "gymnastic step" was the terror of these well intending veterans; after one or two minutes of the run, they could be seen leaving the ranks out of breath, while the younger ones, whom they had left behind on the long marches, kept on for a considerable time without feeling any obstruction to their breathing. Serious accidents were sometimes produced in these movements, when they were commanded by too zealous officers who forced the men to keep up their speed notwithstanding the difficulty in their breathing; and national guards were sometimes seen, from having run too long in the face of threatened suffocation, to fall in their places, struck with pulmonary congestion.

Exercises of force would also be as badly chosen for elderly men as exercises in speed, and for the same reason—that they fatigue the blood vessels and the heart. Every muscular act that requires a considerable display of force inevitably provokes the physiological act called effort. A porter in lifting a heavy burden is obliged to make an effort, as does also the gymnast who executes an athletic movement with his apparatus. These are common facts of observation, and impressions which everybody has felt. If we put all possible energy into any movement, respiration stops at once, the muscles of the abdomen stretch, and the whole figure is stiffened, while the veins swell and mark salient sinuosities on the neck and forehead. I have explained the mechanism of effort in my book on the Physiology of Effort. It is enough to recollect here that it increases in excessive proportions the tension of the blood vessels. Effort is translated, in fact, by a considerable pressure of the ribs on the lungs, and through this upon the heart and large vessels; under the influence of this pressure there is a reflow of the mass of the blood toward the smaller vessels and distention of their walls. When these vessels are tending to lose their elasticity, in consequence of the modification of structure observed in mature age, the violence to which the effort subjects them results in the aggravation of their inert state. In the same way the "fatigue" of a steel spring which has had too much to bear is increased again after very violent pressure to which it is subjected. Nothing wears out a man who has reached maturity like great physical efforts, because nothing can more than effort aggravate the effects of that defect of nutrition which is called sclerosis.

In some cases arterial sclerosis is nothing but the gradual and slow consequence of the advance of age, but assumes a rapid pace that makes it a fearful malady. In such cases we can see young persons presenting the same physiological reactions against fatigue as the elderly man. One of the first symptoms of that acute aging of the arteries which is called arterial sclerosis is the dyspnœa of effort.* All elderly men are, in different degrees, tainted with arterial degeneracy, and all ought to avoid excessive muscular effort if they would not wear out their arteries before the time—that is, would not grow old prematurely; for every man is "of the age of his arteries."

While the elderly man has less capacity for some forms of exercise than the younger adult, he has no less need than the other of the general and local effects of exercise. It is in the earliest period of mature age that the most characteristic manifestations of defects of nutrition—obesity, gout, and diabetis, in which lack of exercise plays an important part—are produced; and the treatment of them demands imperiously a stirring up of the vital combustion. Placed between a conviction that exercise is necessary and a fear of the dangers of exercise, the mature man ought, therefore, to proceed with the strictest method in the application of this powerful modifier of nutrition. It is impossible, however, to trace methodically a single rule for all men of the same age, for all do not offer the same degree of preservation. We might, perhaps, find a general formula for the age at which the muscles and bones have retained all their power of resistance, and at which the heart and vessels begin to lose some of their capacity to perform their functions. The mature man can safely brave all exercises that bring on muscular fatigue, but he must approach with great care those which provoke shortness of breath.

The formula is thus subjective in its application, in the sense that it looks rather to the feeling of the person than to the exercise itself; and from this point of view it is exactly applicable to all. One person is taken with shortness of breath at the beginning of a fencing bout; another one of the same age can fence without losing breath, while he tires his legs and arms. Most frequently the question of measure in the practice of exercise is more important than the choice of the kind. Some exercises are dangerous only on account of the temptation they offer to impetuous temperaments to pass beyond reasonable bounds. Thus fencing, which prematurely wears out too enthusiastic swordsmen, may remain a very hygienic exercise for the man of fifty years, provided he is enough master of himself to moderate his motions. There are exercises, however, which of themselves imply the necessity of a violent effort or a rapid succession of movements; among these are some of the exercises with gymnastic apparatus, wrestling, and running. These should be absolutely prohibited to the elderly man. This rule cannot be invalidated by the rare examples of men who have been addicted to such exercises till an advanced age. Such men have continued, in respect to their structure, younger than their age; they have kept their elastic arteries as other persons keep their black hair. They are physiological exceptions, and general formulas do not regard exceptions.

The need which the elderly man feels of a stimulation of his organic combustion may be satisfied in other ways than by exercises of strength and agility. It is, in fact, the sum of work that regulates the quantity of heat expended by the human body, and that is proportioned to the quantity of tissues burned, to the amount of oxygen consumed in the acts of vital chemistry that constitute nutrition. It is possible to reach a considerable sum of daily work without at any moment making intense exertion or rapid movements. The muscular acts of exercises chosen have for that only to be continued long, without being very violent or very rapid. In other words, it is enough that the exercise represents "bottom" work.

Walking is the type of "bottom" exercise, and is the most hygienic of all kinds for the elderly man, provided it is prolonged enough to represent a sufficient amount of work. Nothing is so good for the man of fifty years as a gunning tramp, or long pedestrian tours like those the Alpinists make. But it is necessary to regard the social exigencies, which refuse to give everybody the desired number of hours, and compel another choice. There are many other "bottom" exercises that exact a larger expenditure of force than walking, without going beyond the degree of effort and rapidity that the arteries of the elderly man can safely bear. Many of what are called open air games, like tennis, lawn tennis, and even rowing, when practiced not for racing but as a recreation—that is, with a liveliness graduated to the respiratory capacity of the rower—provoke, for example, in one or two hours, an elimination of the products of disassimila-

* Author of the Physiology of Exercise.

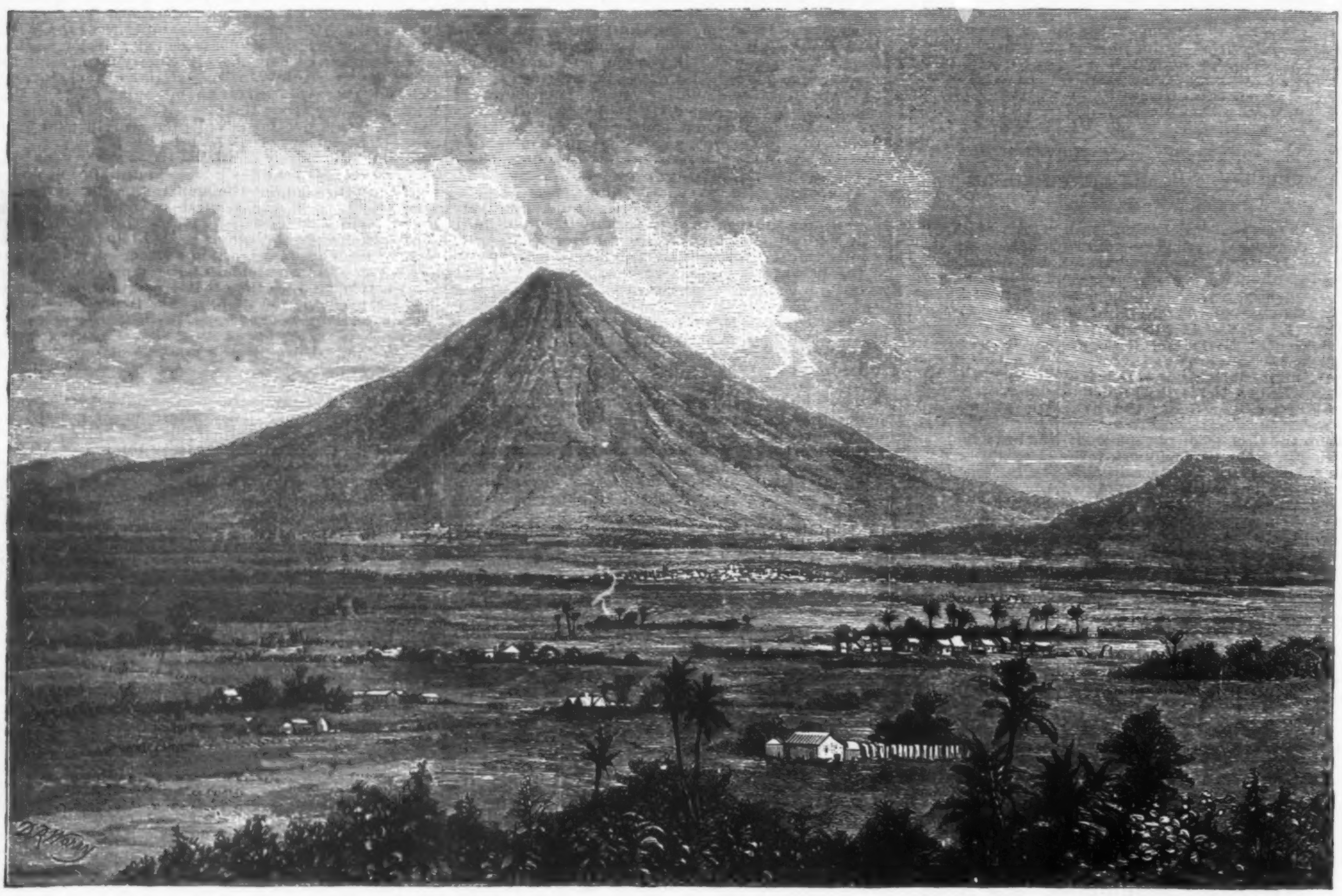
* See Huchard, Maladies du Cœur et des Vaisseaux, 1889.

tion and an acquisition of oxygen equivalent to what one can get from eight or ten hours' walking. They permit the busy man to gain time, compensating for the shorter duration of the exercise by its intensity; but that in such a way that he can get the general consecutive effects of exercise while avoiding its general immediate effects, super-activity of the circulation of the blood and of respiration.

We ought to look also to exercise for local effects; in order, in the first place, to keep the joints supple and counterbalance the tendency to incrustation of the cartilages, which is one of the consequences of age; and, in the second place, to keep the muscles as a whole in sufficient strength and volume. The muscle, as we have read, is "the furnace of vital combustion," and in developing the muscular tissue we favor the activity of combustion and the destruction of the refuse of nutrition. For the satisfaction of these requisitions, such exercises are adopted as might be called analytical, inasmuch as they bring the whole muscular system into play, not by the work of the whole together, but by a series of successive movements that call the various muscular groups into action severally one after the other. It is important, in order to preserve the easy working and suppleness of all the articulations of the body, to subject them to movements extending to the extreme limit of possible displacement. We might also, by localizing the work successively in limited muscular groups, effect very intense muscular efforts without any fear as to their reaction upon the organism or upon the circulation of the blood. The floor exercises of the Swedish gymnastics exactly fulfill the conditions needed to obtain suppleness of the joints; similar exercises, according to the French method, would be well fitted for the object of preserving or increasing the local muscular development.—*Translated for the Popular Science Monthly from the Revue Scientifique.*

## EARTHQUAKE IN CENTRAL AMERICA.

THE smallest in extent, and the least frequently involved in transactions with European financial or diplomatic agencies, of the Central American or semi-Spanish republics, San Salvador is most renowned for its tremendous earthquakes and volcanic eruptions. It occupies a little space on the Pacific Ocean coast, from Guatemala, on its western frontier, to the Bay of Fonseca, and borders on Honduras to the north and east. Seaward, it has a coast of moderate elevation, with a strip of fertile soil intersected by the Rio Lempa and the Rio Sumpul, and with lovely valleys, behind which rises a mountain ridge containing eleven conical peaks that are burning volcanoes. The city of San Salvador, the capital of this little state, on the sea coast, has been thrice destroyed or partly destroyed within our remembrance, either by earthquakes or by eruptions of the neighboring Mount Izalco—namely, on April 16, 1854, on May 19 in 1869, and again in March, 1873. We now learn, once more, that on Sept. 9, after several days' volcanic activity of the craters of San Miguel and Izalco, with deep subterranean rumblings and earth tremblings, the inland country was devastated by a terrific earthquake, which leveled to the ground a number of towns, including Analquito and Comasagua. Hundreds of people have been killed, and the amount of property destroyed is enormous. The towns in the country, on this occasion, suffered more than the capital. The country is, on the whole, thickly populated, with 435,000 inhabitants, of whom only 10,000 are pure whites, and at least half the people are of the native Indian race.—*The Graphic.*



VALLEY OF JIBOA, SAN SALVADOR, SCENE OF THE RECENT EARTHQUAKE.

## PUITS DE PADIRAC.

GEORGE C. HURBUT in *Frank Leslie's Monthly:* The region of Les Causses, in Central France, is one of the most remarkable in the world for wild and fantastic scenery, resembling upon a smaller scale that of the Great Cañon of the Colorado, which, however, has nothing to show like the great pits and caverns, and underground rivers of Les Causses; while the vertical walls and cliffs through which the Tarn, the Joute, the Tarnon, and other streams wind their way, rising from 800 to 1,900 feet above the head of the tourist in his boat, and satisfying his sense of the wonderful in nature, leave him no inclination to recall comparative measurements. It is with Les Causses as with the Alps. In both the scale and the area, though restricted, are still so vast, so inexhaustible in their contrasted manifestations of power, that they leave an ineffaceable impression of sublimity.

Among those who have explored these strange formations in Central France, Mr. E. A. Martel is the most indefatigable worker. His latest contribution to the knowledge of Les Causses is an account of Puits de Padirac, which is situated in the Causse de Gramat, in the department of Lot, not far from Rocamadour, a celebrated place of pilgrimage.

The Abyss (Gouffre) of the Puits lies open to the sky in a level field, with nothing to indicate it till the very edge is reached, and there the wanderer recoils in terror. The hole is over 100 feet in diameter, almost circular, and 160 ft. deep. Animals frequently fall into this gulf, and twenty-five years ago a man pitched into it. His body was recovered after great effort, and those who descended into the pit found no time, and, it may be, had no inclination to explore a broad archway, or natural door, at the bottom. Through this archway, which is visible from the edge of the pit, it is affirmed that a brook rises in very rainy winters, crosses a part of the pit, and then disappears through a side cleft.

In July, 1889, Martel, with three companions, arrived at Puits, determined to pass beyond the mysterious door. A rope ladder was secured and let down, swinging freely at the bottom, where the diameter is much greater than that at the opening of the pit. Mr. Martel was the first to descend, and found himself landed on a pile of stones, with the true bottom still sixty feet below him. After making a plan of the pit and arranging their apparatus for photographing and the telephone, the party turned to the archway, which was found to be over thirty feet wide and 100 high. From below came the sound of running water, and the explorers were glad to move toward it, for the place where they stood was heaped with the decaying bodies of the animals that had fallen from above or had been thrown there by the peasants to get rid of them.

About 150 feet beyond the arch the party came upon the stream, which disappeared on the left hand through a fissure in the rock; but on the right a low gallery, through which it was necessary to crawl, led in a curve like the letter S for 500 feet to a little spring, from which the stream flowed. Returning to the Puits, Mr. Martel found opposite the great archway a horizontal opening from three to six feet wide. He and his companions passed through this opening into a little grotto, which led to another below it; and here they found the brook larger in volume than where it had disappeared, and filling a pool fifteen or twenty feet in diameter, and pouring over beyond through a passage from fifteen to thirty feet wide, and with a vaulted roof nowhere lower than thirty feet and sometimes rising to 130 feet.

They followed this passage, which turned again and again at a sharp angle, for 1,200 feet to where the brook had become a river many feet deep. It was late in the afternoon, and the little boat in which Mr. Martel had made more than one subterranean voyage had been left behind. It was a principle with him not to pass the night underground, and so the way was retraced along the Guano Gallery, as the passage was called from the pungent deposit with which the millions of bats had covered the rocks. Returning the next day with the boat, the Crocodile, Mr. Martel and one companion embarked on the river, leaving the other two to wait for them in the gallery.

For 1,300 feet the boat moved on the broad, deep stream in perfect silence. The passage was twenty feet wide between the high, smooth walls. The first obstacle was a stalagmite, over which it was necessary to lift the boat, which floated on successively through four oval expansions of the gallery, each a dazzling grotto filled with the most beautiful and fantastic forms of stalactites, fonts, bouquets of flowers, bass relief, acanthus leaves, statuettes and brackets—every imaginable decorative form, pure white and rose pink in the splendor of the magnesium light, reflected from the mirror-like surface of the water; and over one of the lakes a red and yellow stalactite, fifty feet long and twelve feet in diameter at the roof, descended, gradually lessening to a point, to the water.

"Here," says Mr. Martel, "even the water of the stream makes no noise. We hear the fall of the drops from the vaulted roof on the river and on the stalagmites, with a silvery clear or duller sound, repeated and combined in the echoing space into a soft music, more harmonious and more penetrating than the sweetest earthly notes. No human being had preceded us in these secret depths; no one knows whither we are going, or what we see; we are isolated in our boat, far from contact with the life of the world. Never have we looked on any scene so strangely beautiful, and we turn to each other with the question: "Is not all this a dream?"

Beyond the lakes the navigation, which had been very easy, became more and more difficult, the chief obstacle being the numerous natural dams, formed by semicircular stalagmites, with the convexity downstream. These dams held the water like basins, and resembled the hollows worked in the beds of rivers by the plunge of waterfalls.

To these hollows the country people give the name of *gours*, and Mr. Martel adopts this for the stalagmite dams. There were thirty-four of these to be passed by lifting the boat over them; the lowest rose eight inches above the surface, the highest twenty feet; and the largest of all was more than forty feet in length.

At the lower end of the last lake the stream flowed between two stalagmitic columns, sixty or seventy feet in height, and only three feet apart. There was

just room for the Crocodile to squeeze through, and the place received the name of the Pas du Crocodile.

Beyond the third dam, or gour, the roof of the vault shut down to within twenty inches of the water, and it required a half-hour's work to get through the twenty feet of this passage, Mr. Martel's companion lying on his face in the boat, and breaking off as he passed the stalactites that hung down, and Mr. Martel creeping through a narrow crack on the left. The explorers took a little hard-earned rest further on by the side of a lake 200 feet in diameter, with several gours and a number of stalagmitic islets breaking its surface. They were now about three-fifths of a mile from the great pit; but they pushed on for as much more without reaching the end, and then decided to return to the opening. It was 7 o'clock when they emerged into the upper air, and sat down to a much-needed repast with their friends gathered about them in the light of a superb sunset.

It was not till September, 1890, that the unfinished task was resumed. Reports of the wonderful discoveries had spread from place to place during the year, and when the explorers arrived at the edge of the Puits they found more than one thousand persons collected to see the start. The descent from the surface was safely made. A little balloon was sent up as a farewell to the crowd, and was hailed by a shout of applause, and the adventurers, with a last look at the heads peering down from the brink of the abyss, plunged into the dark.

At the last point reached the year before a slope, inclined at an angle of thirty-five degrees, rose before the party to a height of 160 feet. It was a gour of stalagmite pure as white coral and inclosing a lake of sixty feet in diameter. From the top of the gour, which was wide enough to walk on, the view took in the lower lake, with the three boats floating so many feet below on the crystal water in the strange white radiance of the magnesium light.

The formation of the stalagmites here recalled that of the Mammoth Spring in the Yellowstone National Park, and the great hall, the largest in Padirac, 200 feet long, with a breadth of 130 feet, and a vaulted roof 160 feet high, received the name of the Salle des Sources du Mammoth.

There were but two more dams or gours; the thirty-sixth and last of all being a ridge of slippery clay. This passed, the stream all at once disappeared, and the explorers advanced on foot through a gallery 700 feet in length, and came upon another lake, the eleventh in order. A boat was brought from the gallery, and two of the party embarked. The lake was about 300 feet long, and a narrow passage led from it into the twelfth lake, 200 feet in length, and at the further end of it a little sandy beach closed it in. A narrow alley 30 feet long led to the solid rock, without a crevice or a cranny.

It was the end of Padirac. The subterranean river is 1·8 miles in length. Its source is 338 feet below the surface, and its termination at a depth of 427 feet. Mr. Martel thinks it probable that the waters stored up in this immense reservoir find their way by infiltration to the different sources of Gintrac, one and one-fourth miles to the northwest of the extreme point attained by his party, and very near to the River Dorgone, and at least 320 or 330 feet above its level. This would be about 400 feet below the opening of the Puits de Padirac.

## THE FAUNA OF EASTERN TURKISTAN AND THIBET.

In the steppes between the Lob-Nor and Tengri-Nor there graze immense herds of wild yaks (*Poephagus grunniens*), a sort of buffalo covered with thick hair, and indigenous to Thibet, where ages ago it was reduced to domesticity, and where it rendered the inhabitants varied services. Its coat serves for the manufacture of thick and strong fabrics, its tufted tail is used for making standards, its flesh is nutritious and its milk does not cede in quality to that of our domestic cow, and, finally, as a beast of burden and draught animal, and even as an animal for riding, the yak is highly valued by the Thibetans because of its strength and sure-footedness. This is why in the spring of 1854 an importation into France through the care of Mr. De Montigny, the French consul at Shanghai, of a herd of eleven yaks, males and females, some white and provided with horns similar to those of our native oxen, and others black and hornless, was received with joy. The highest hopes had been founded on this herd, which was divided between the Menagerie of the Garden of Plants and different land owners; but the animals unfortunately soon degenerated in our climate. Up to recent times, the stuffed skins of a few of these yaks introduced into France, or of their descendants, alone represented the species of the *Poephagus grunniens* in the galleries of the Museum; but this establishment now possesses a magnificent specimen of the wild yak, which was killed to the south of Lob-Nor by the Prince of Orleans, and the skin of which, carried with great difficulty on horse or camel back through Thibet and Tonkin, was admirably prepared by the skilled taxidermists of the laboratory of Buffon street (Fig. 1). On comparing this specimen with the older ones, it is easy to see what modifications the species has undergone under man's influence, and in consequence of a change of environment. In fact, in the domestic yak, the coat, which is remarkably fine, is often of a silvery white or of a gray color varied with white, and the horns, when they are not atrophied, are simply curved outwardly and upward (Fig. 2). On the contrary, in the wild yak, the coat is of a uniform black or slightly tinged with brown, and the horns, which measure nearly three feet, describe an incomplete S, being directed outwardly, then forward and then upward, as may be seen in Fig. 3. Besides, in the wild bulls, such as the one presented by the Prince of Orleans to the Museum, the stature is always much greater than in the domestic yak, the height of the withers reaching nearly six feet, and the long hair that covers the sides and the legs descending much lower than in the individual figured by Przewalski in his work on Mongolia. It may be conceived that the hunting of such an animal is attended with serious danger, for it is very difficult to fell it with the first blow, and, when it is injured, it often rushes with fury upon its adversary.

The old bulls usually keep themselves at a distance from the herd, which often comprises a hundred heads, and even more, and which consists of females, with their calves, and young males. These herds graze upon the plains and mountain sides at an altitude of from 13,000 to 16,000 feet, and, in the north of Thibet, sometimes live side by side with the koulans and the beautiful antelopes with thick muzzle, woolly coat, and annulate horns that first rise vertically and then separate from each other toward the extremity. A specimen of this antelope, which is scientifically called *Pantholops Hodgsoni*, and which is known to the Thibetans under the name of orongo, figures in the same case with the kiangs.

On crossing the Altyn Tagh, a chain of mountains that extends from west to east, the Prince of Orleans and Mr. Bonvalot observed upon the rocks a few mufflons (*Pseudovis Burrhal*) and quite a number of argalis (*Ovis Polii*), provided with monstrous horns twisted like a corkscrew, and similar to the fine specimens presented to the Museum a few years ago by Messrs. De Breteuil and Ridgway. In Thibet, properly so called, they killed a host of carnivora—foxes (*Vulpes ferrilatus*); lynxes, some spotted and others of a uniform tawny color; ounces, panthers; cats of small size (*Felis manul*), quite similar to our Angoras, if not in color, at least in the thickness of the fur; martens; badgers, differing from the European species in the dentition; and bears, with variegated tawny coats, with a wide light collar (*Ursus collaris*), and which are called djemos by the natives, and sometimes attain a huge size. They likewise obtained a very large number of rodents, gray and red squirrels (*Sciurus erythrogaster*); flying squirrels with red hair on the back and a white face, belonging to a species (*Pteromys alborufus*) which had already been met with in another part of Thibet by Abbot David, and which has been described by Milne-Edwards; rats; marmots (*Arctomys robustus*), the skin of which is often used by the Thibetans for making gun cases; hares, properly so called; lagomyses (*Lagomys Dedekensi* and *erythrorhynchus*), small rodents that belong to the same subdivisions as the hares and rabbits, but which are of much smaller size, and are met with only in Alpine regions. Finally, the expedition brought back several monkey skins from Thibet, and even a young living macacus, which was immediately placed in the menagerie of the Museum.

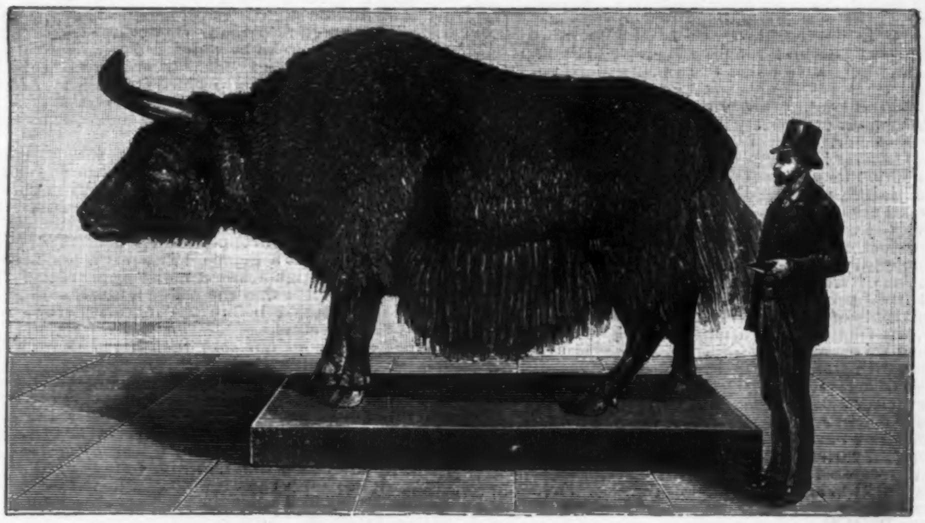


Fig 1.—WILD YAK KILLED BY THE PRINCE OF ORLEANS.

In this enumeration we have, of necessity, omitted many species, and even some very remarkable ones, such as the *Grandala cœlicolor*, which in summer lives in the vicinity of the eternal snow, and which, from the color of its plumage, seems to be the "blue bird" of the legends. But the list that we have given amply suffices, we think, to demonstrate the value and the importance of the collection made by the expedition of Mr. Bonvalot and Prince Henri of Orleans, especially when we consider that we have taken into account only the mammals and birds. To this collection, which comprises several hundred specimens generously presented to the Museum, are still to be added some other specimens that the Prince of Orleans has received from the Tatsienlou Mission, and among which are antelopes (*Nœmorhedus Edwardsi*), ruminants intermediate between the antelopes, goats, and sheep; deer and several species of birds; lophophores, tetraogalles, etc., which are to be placed in the galleries of the Museum alongside of the specimens collected by Abbot David. —*La Nature.*

Fig. 2.—HEAD OF DOMESTIC YAK.

Fig. 3.—HEAD OF WILD YAK.

## POMOLOGY.

The American Pomological Society recently held its twenty-third biennial session at Washington on the invitation of the secretary of agriculture. The following report is from *Garden and Forest.* As a rule, the society accepts the hospitality of some local organization, but in this instance the gathering was welcomed by the Honorable Edwin Willets, the assistant secretary of agriculture, in the lecture hall of the National Museum. During the sessions papers were read by several of the experts connected with the department, and all the material of the department in the way of fruit models, etc, were placed at the service of the society.

The fruit exhibit, which the older members say has not been so good of recent years as it was twenty-five years ago, was very creditable in every way. The state of Virginia, through her commissioner of agriculture, showed one hundred and sixty-three varieties of apples, which represented all the fruit regions of the state, from tide water to the mountains, and many of them, notably the Albemarle pippins, were exceptionally good. From Mississippi, Tennessee, New Jersey and many other states there were promising seedlings, and Messrs. Ellwanger & Barry had a very large display of pears. Of the minor exhibits there was a striking collection of citrus fruits from Florida shown by the Rev. Lyman Phelps, with some admirable pines from the same state by Mr. H. S. Williams. President Berckmans exhibited an interesting collection of Japanese persimmons of all sizes, shapes and colors, and Mr. H. M. Engle, of Pennsylvania, some of the remarkable chestnuts which he is growing.

A good deal of time was spent on the revision of the catalogue, which is really one of the most important functions of the society, but very plainly it is a difficult matter for a few members in the hurry of such an occasion to pass any such deliberate judgment as they deserve on the merits of fruits and their adaptation to different regions. Mr. Berckmans' suggestion, in his address, that this work should be practically done by local societies, under the supervision of the national one, commended itself to all of the members. We give below a few of the more important paragraphs from

this address, which was a general survey of the field and a careful record of pomological progress since the meeting of the society in Florida two years ago. The officers chosen for the next two years are Prosper J. Berckmans, of Augusta, Georgia, President; C. L. Watrous, of Des Moines, Iowa, First Vice-President; G. B. Brackett, Denmark, Iowa, Secretary; Benjamin G. Smith, Cambridge, Massachusetts, Treasurer.

### THE PRESIDENT'S ADDRESS.

In speaking of the work of auxiliary societies, Mr. Berckmans said:

These local organizations could hold meetings every month, or even oftener if need be, especially during the fruit season, and at these meetings the merits and demerits of fruits could be ascertained, annual reports made to the state society, to which these local societies should be auxiliaries. In this way the chairmen of state fruit committees could collect more reliable reports than could be obtained where state and district societies do not exist. Our state reports are in some instances deficient in reliable and practical information. To persons unacquainted with the scope of our state reports and their influence in bringing the most desirable class of citizens to their borders, let me say that one of the main considerations a prospective settler takes in view is the adaptability to successful fruit growing of any section where he intends to make his residence. The state which gives the most comprehensive and reliable report as to its advantages in these productions will receive the most intelligent, energetic and desirable addition to its population; and that community most exclusively devoting itself to fruit growing and horticultural pursuits is found to advance more rapidly in everything tending to elevate, refine and enrich its citizens.

In urging the necessity of scientific pomology, Mr. Berckmans argued as follows:

While this society has never deviated from its original object, which is the advancement of the science of pomology, yet the wonderful strides made in the production of fruits make it imperative to give commercial fruit growing all due attention, inasmuch as the magnitude of that source of production is, in a measure, the result of the scientific work of this society. When we compare the wonderful array of the various fruits with which our markets are now supplied with those of a generation past, well may we feel amazed at the variety and abundance as well as improved quality of our market products. A few years ago many fruits were offered in such limited quantities that the names of special varieties were almost wholly ignored. Strawberries were all strawberries; the Isabella was the only name used to specify a variety of grapes that could be found, and among pears the sugar top was synonymous to the Bartlett, and every orange, good, bad or indifferent, was sold as a Florida orange. Now, on the contrary, the market reports issued by every commission man who values his interests name the varieties of all classes of fruits, and quotations are made according to their value. Purchasers have become gradually educated to the knowledge of the best varieties, and thus inferior sorts are driven out of the market. With these facts in view, commercial fruit-growers are interested in improving our popular varieties of fruits by the most careful methods of cultivation, picking, sorting and packing, and they can increase their pecuniary returns by promoting the advance of scientific pomology.

### THE HYBRIDIZATION OF PLANTS.

Professor Charles E. Bessey began a paper on this subject by saying that in the lowest forms of vegetable life the process of reproduction is exceedingly simple—that is, one plant divides itself into two; each new plant divides again, and so on indefinitely. But when conditions are not so favorable, reproduction takes place in a general way as follows: Two of these free-swimming aquatic plants come together and merge their substance into one another—that is, fertilization consists simply of two entire plants or parts of plants which fuse into one, and lose their previous identity. This means the simple union of two individuals for the sake of strength and production. The united plant is able to live and resist adverse influences, which otherwise would have destroyed the single plants. The two plants after union become one round body, and this covers itself with a protecting shell, and since the larger the mass is, the smaller proportionally is the exposed surface, the united plant needs less covering than the two did before the union, thereby saving both material and force. Thus the union of the two into one mass has saved the life of the individual and has perpetuated the species. This is essentially what takes place in all plants where there is anything like fertilization. The law is that fertilization is the union of two masses of living matter.

In the fertilization of flowering plants we have the same coming together of individual masses, and as a consequence of the union of the male and female cells there begins a growth in the young seed which results in the formation of the embryo which is to be found in every seed.

This fertilization, that is, the joining of the substance of the pollen-cell with that of the seed-cell, does not differ in any essential respect from that which takes place in the simplest plant.

The old distinction between crossing and hybridization is one which has nothing like as much importance as at first sight it would seem to have. If varieties differ from species only in degree, then crossing of varieties differs from hybridization of species also only in degree. Furthermore, it is well known that no two animals are ever exactly alike. No two plants are ever exactly alike, even where they belong to the same variety; and therefore when the pollen is taken from the flowers of one plant and carried to those of another, there is a slight crossing of kinds. It is not as great as when the pollen is taken from a flower of one variety to that of another, nor by any means as great as when it is taken from the flowers of one species to those of another, but all these differ only in degree.

Whenever crossing takes place, the offspring will partake of the character of both parents. This follows as a necessity from the nature of the act. We have seen that in any fertilization there is a union of two plants, or two parts of plants, and in crossing the male organ belongs to one variety or species, while the female organ belongs to another. When these two organs are joined the result is a union of the character of the two varieties or species. In this way the offspring must partake of the nature and characteristics of its parents. It is impossible for it to be otherwise. Now, it has been noticed in the breeding of animals, and to a certain extent in the breeding of plants, that the two parents do not always exert the same influence upon the offspring. In the case of many natural crosses which take place between the wild species of plants, noticeably in the Verbenas, the Oaks, the Willows and others, we have been able to detect this difference with such certainty that it is not at all a difficult thing to tell whether, in the case of any particular cross, the pollen comes from this or that species.

In nature, crossing is accomplished largely through the agency of insects, but when we bring this matter within the domain of horticulture we cannot afford to depend upon such precarious aid. The time is coming when the grower of fruits will as carefully select the parents for his crosses as the grower of fine animals now does. The grower of plants, however, has one advantage over the grower of animals. He need not pen up his plants, he need not grow them in different greenhouses or in different fields. As the pollen of our fruit trees is always yellowish, there is no difficulty in handling it upon the black point of a hair pencil. The pencil should be slightly moistened, so that the pollen will adhere to it, and then, when loaded with pollen from one flower, it can be gently brushed over the ends of the pistils of the next one. In order to be sure that the stamens of the flower to which the pollen is brought do not themselves drop pollen to the pistils, it is well to remove them at once by clipping them out by means of a delicate pair of scissors.

This operation is not difficult. It simply requires care in watching for the exact time of the maturity of the flower, and then a very little skill will enable one to place the pollen. The maturity of the flower may be told in the following way. The stamens are matured when they are dropping the pollen. This can be seen by any one at a glance. The pistils are matured when the top stigma has a moist appearance. This moisture is what makes the pollen adhere, so that any attempt at crossing before the maturity of the pistil would be ineffectual.

There can be no question that horticulture will be greatly benefited when horticulturists begin to breed varieties scientifically. It is a well known fact that the seeds of apples, taken from any particular tree, will produce all sorts of variations. Now, the secret of this is that the flowers which produce these seeds had been crossed with pollen taken by insects, perhaps, from a dozen different kinds of trees. Furthermore, all our apple trees are now of mixed blood, and we know very well what that means, especially in the animal kingdom. Now, careful experiments should be made by members of this society. Suppose that you select two apple trees which are not far from one another, and which, for convenience, are not very large. It will be best to select trees of marked varieties. If they are trees which have characters about them which would indicate that they were likely to reproduce their kind and their characters, it would be better still. Now, when these trees are just about ready to flower, cover each one with mosquito netting which has been carefully sewed together, so as not to leave any opening to admit insects. When the stamens on the one tree are just bursting open so as to shed their pollen, take a soft camel's hair brush, wet it slightly, and carry some of the pollen from certain flowers on the first tree to certain flowers on the second tree. Then carry pollen from the second tree to certain flowers on the first tree. If you remove the stamens from the fertilized flowers it will add much to the certainty of the results. Mark the flowers which you have experimented upon; keep the trees covered with the mosquito netting until the flowers wither, and then remove it. Carefully note the growth of the apple during the season. Notice whether the flesh of the apple has been changed in any way, and when the fruits are finally cut up save the seeds for planting. When these seeds have grown, cions should be taken from the young seedlings and placed upon old trees, so as to bring them into bearing at the earliest possible period. It will be very interesting to compare the results of such crossing. If the parent tree possessed marked characters, we should expect to find these reproduced in a modified way in the offsprings.

Similar crosses may be effected between varieties of vines, and it is still easier to secure early returns from the experiments. Cherries, plums, and even the ordinary small garden fruits may be experimented upon in the same way. If the members of this society were to plan a series of experiments, each man confining himself to a single one, within the next ten years we should without doubt have some surprising results.

It is by the application of exactly these principles that the breeders of animals have been able to reach the results with which we are so well acquainted. It still seems to us in horticulture rather a theoretical thing when we talk of crossing and breeding in order to produce new and desirable species, but that which has proved of such great value in the animal kingdom will in like manner prove of value in the vegetable kingdom.

The horticulturist of the future, and of the near future, too, will be a breeder of plants, and he will be able, by judicious crossing, by intelligent working for a particular form, to control the results of his breeding.

### SUCCESS WITH SMALL FRUITS.

Mr. J. H. Hale delivered an address on this subject. As a first requisite he named a thorough preparation of the soil. Such a recommendation seemed hardly necessary, but in a great majority of cases fruit growers fail for lack of attention to this fundamental matter. Of course, in the virgin soil of the prairies different treatment is needed from that required in thin and worn lands in the Eastern States, but there is the same necessity of deep preparation and thorough drainage, although there is less necessity for fertilizing, which is the second requirement wherever the soil is not absolutely rich. For small fruits, potash and phosphoric acid are the plant foods principally needed in Connecticut. Wood ashes is the most effective form in which potash can be used, but in the South, where it can be obtained, the ashes from cotton hulls is better still. Two hundred bushels of ashes to the acre is not too much, and to this a ton and a half of finely ground bone may be added to supply the phosphoric acid. Ground bone had proved the best form in which phosphates could be applied, but South Carolina rock and other forms of phosphate should be tried. As a rule, but little nitrogen is needed, since the tendency of this is to make a growth of foliage. Of course, in certain instances it is valuable, as, for example, while the Cuthbert and Golden Queen raspberries will flourish under treatment of potash and phosphates only, the Marlborough, in the same field, would be improved by the addition of a trifle of nitrogen, because it is a feeble grower, and needs strengthening. (In other districts nitrogenous manures have proved essential to the highest success with small fruits.)

It is a great mistake to grow the plants too thickly. It generally happens that from two to three times as many raspberries, for example, are planted to the acre as can be grown to advantage. They should not be set closer than six feet apart each way, and seven, or even eight feet apart, are better for strong growers like the Cuthbert. Then the berries will be big, bright and firm. Hedge row culture and matted row culture is wrong, and the hill system is right almost always. Berries grown in this way will be superior in size, texture and quality, and will yield more quarts to the acre, and, besides, the cultivation will cost less when it is done thoroughly.

Irrigation should be provided for strawberries, where it is at all possible. The grower cannot afford to take all preliminary care for thorough preparation and painstaking cultivation up to the time the plants bloom, and even up to the time the green berries appear, and then lose all on account of the failure of rain for a few weeks. At such a time the control of a supplemental water supply is invaluable.

After the crop is grown the marketing demands much thought and study. Fruit growers often work too hard and think too little. It pays to study fruits as they come into the market and to mark the different styles in which they are offered. Fruit which is nicely topped, but does not run uniformly throughout the package, may sell well for a time, but in the long run that grower is always sure of a market who has his best fruit at the bottom, and who is willing to stamp his name and post office address on each package, so that the people who buy his fruit will know whom to address when they want more of just the same sort. As an instance of success Mr. Hale cited the case of a man who was careful to select and grade every basket of his strawberries, and in the bottom of each basket he placed a card bearing his name, the name of his farm, with the date and the hour of the day in which the fruit was picked added in stencil, and after all this, in big type, was the legend, "This fruit will cost five cents more a basket than the market price."

The eye of a buyer must first be pleased, and the value of an attractive style of placing fruit on the market cannot be overstated. A strawberry grower in western Massachusetts found that it paid to put a rosebud on the top of each basket in the crate, for these decorated packages would sell when no other ones were wanted. The most certain way of securing a market for fruit is to establish a reputation. A grower must make his name have a positive value. He must persist in careful selection and uniform packing until buyers know that his berries are certainly of the first quality and can always be relied on. A name which stands for all that is best in the possibilities of fruit culture will always sell the fruit upon which it is found.

After all, the home is the best market for American fruit growers. The average American family uses too little fruit. Farmers, and even orchardists, rarely have enough small fruit. They say it does not pay to raise berries and they can buy all they want. Really they buy a few now and then instead of having an abundant supply every day. Half a bushel of fruit the year through can be profitably disposed of by the average family every day. Every one with half an acre of ground to devote to the purpose can have enough small fruit for home use. This does not mean a few berries in a corner of a garden, but a full line of the standard varieties of all kinds of small fruits planted in long rows, so that they can be cultivated by horse power, yielding an assured abundance for the table, for canning, etc. Last year a Connecticut farmer kept account of the fruit which he supplied to his family from half an acre of ground. He watched the markets and charged his family with the price of all they consumed, and it amounted to $365, or more than $700 per acre. This was the actual money value of what the consumed fruit would have cost, but the account makes no mention of the pleasure and zest which the product brought to the table in that household, nor of the beauty of the garden, which was an ever-changing picture for the enjoyment of its owner and his family, nor of the advantages from the healthful out-door habits it encouraged, nor of the delights of tasting new fruits, or the hundred other subtile ways in which a garden ministers to mental and physical health.

### NEW AND PROMISING SMALL FRUITS.

The paper of Mr. J. T. Lovett on this subject covered all kinds of small fruits, but we only have space for the following:

But little of interest is to be found among new varieties of the currant. Fay's Prolific is a success with me, and I hear none but good reports of it from any quarter. North Star gives promise of being a valuable variety, especially for the market grower. Black Champion is an improvement upon the old Black Naples; the berries are larger and produced in greater abundance. I am told it is of better quality, but to me all the black currants are repulsive, in odor and flavor. The Crandall has some merit for culinary purposes. It is of strong growth, exempt from the attacks of insects and disease and very prolific; but the fruit is too harsh and austere to be acceptable as a dessert fruit. The berries are exceedingly large, almost equaling in size the Delaware grape, and are decidedly attractive. The claim that a good jelly can be made from it is founded on fact, as I can bear witness.

The Industry gooseberry has not proved as successful with me as it has in many other places. In Monroe County, New York, and upon the Hudson River, it is giving the greatest satisfaction. I also saw it fruiting in perfection in Atlantic County, New Jer-

sey, the past season. Although the best of the foreign varieties I have yet tasted, it loses its leaves prematurely and fails to ripen its fruit.

The dwarf juneberries have given considerable satisfaction at the East. The chief complaint has been that the plants do not yield heavily enough, and that the berries and foliage are attacked by a fungus. The variety known as Success is an improvement upon the type in point of size of fruit, quality and productiveness, and has suffered less from the attacks of fungus than the common dwarf variety. It has suffered also to a slight extent. I find the juneberry much better for canning, pies, etc., than as a dessert fruit. In its natural state it lacks flavor, but when cooked it is quite acceptable.

*Elæagnus longipes* is an interesting fruit. Did it ripen in late autumn instead of July its value would be greatly enhanced. The bush is of low spreading habit, densely clothed with foliage, and it comes into bearing as quickly as a red currant. Its yield is simply wonderful, the berries being literally crowded upon the under side of the branches. The fruit is borne upon slender stems about an inch and a half long, of cinnabar color, with numerous small light gray dots, and about three-quarters of an inch long by half an inch in diameter. It is tender and juicy, with one large, long, shapely pointed seed in each berry, but so acid as to render it unfit for use as a dessert fruit, but useful for tarts—in fact, for all the purposes for which the cranberry is used.

The most entertaining discussion followed an address by Mr. Meehan on the "Influence of Heredity and Environment in the Origination of New Fruits." Mr. Meehan spoke without notes for half an hour very forcibly to prove the baselessness of the notion that any change in varieties could be produced by their surroundings, and he fortified his arguments with a wealth of illustrations drawn from human history as well as from plants and animals under domestication. Dr. Riley attacked the position of Mr. Meehan with great vigor, and Professor Bailey added that he was unwilling to allow it to be placed on record that the American Pomological Society held heterodox opinions on so capital a point, and cited numerous examples of variation in plants which he attributed to their environment. Mr. Meehan replied with great good humor that his critics evidently did not understand what was meant by the term environment; and then Mr. Fernow added that if there was a doubt as to the meaning of the term environment, there was also ambiguity in the use of the term variation, which might be structural or functional, and it was necessary to know whether we were talking about morphological variation or biological variation. The discussion became enveloped in a haze of uncertainty, as it appeared that none of the gentlemen were quite sure what the others were talking about, and it finally closed in a thick fog. It was very instructive and interesting, however, to the laymen.

Mr. J. M. Samuels, the Chief of the Horticultural Division of the Columbian Exposition, was an interested attendant on the meetings, and in the name of Director General Davis he invited the society to hold their session of 1893 in Chicago. He also assured the society that the Director General would appoint any man whom they should name as the head of the Division of Pomology.

We add below extracts from a few of the important papers offered:

### RECENT PROGRESS IN THE TREATMENT OF THE DISEASES OF POMACEOUS FRUITS.

Professor B. T. Galloway, of the Department of Agriculture, read a paper on this subject, which was substantially as follows:

The treatment of plant diseases is a subject of such recent origin that comparatively few are aware of the progress made in this line of work during the past few years. At the Boston meeting of this society, held only four years ago, it is doubtful if any one could have told how pear scab, apple scab, cherry leaf blight, or any of the numerous other diseases of pomaceous fruits, could be cheaply and effectually prevented. Nevertheless, the losses occasioned in this country by some of the maladies of pomaceous fruits have been enormous. Take for example the apple crop. At the very lowest estimate the damage to this one fruit in 1890 by scab alone exceeded six million dollars. The damage done to pears, in both nursery and orchard, by leaf blight, scab and cracking is probably as great as that of the apple. Add to this the damage to cherries, plums, peaches and similar fruits by such diseases as mildew, leaf blight, rot and yellows, and the sum amounts to no less than fifty million of dollars annually. How to prevent this damage is a problem which has long confronted the fruit grower, yet it was not until the year 1886 that the national government, through its Department of Agriculture, established a branch for the investigation of plant diseases. This division, for so it is designated, has been constantly at work since its organization, endeavoring to throw light on the prevention of plant maladies.

The usual method of work is first to make a careful study of the diseases in the field and laboratory, and to follow this with practical field experiments, first on a small scale, and later more extensively if the results justify it. In accordance with a plan of this kind the work on pear leaf blight was commenced nearly three years ago, and is still being carried on. First it was necessary to study the life history of the fungus causing the disease, as it was only with a full and complete knowledge on this point that an intelligent effort in the way of treatment could be undertaken. As a result of the laboratory and field work along this line it was found that to successfully prevent the disease it would be necessary to protect the young unfolding leaves from infection by the spores of reproductive bodies of the fungus which had passed the previous winter in the fallen foliage. As a mere statement this problem may not seem like a difficult one. The fact is, however, that a great many difficulties have been encountered, and while some have been overcome, others remain to be mastered.

The time of the first application, when the leaves are about half grown, being settled, the next questions to solve were, 1, the kind of preparation to use in order to cheaply and effectually protect and not injure the foliage; 2, the number of applications necessary; and 3, the cheapest and most practical means of making the applications. Without going into details it may be said that in treating nursery stock, the best results have been obtained from six or seven applications of the Bordeaux mixture, applied with a Knapsack pump and improved Vermorel spraying nozzle. The Bordeaux mixture is so well known that a description of its preparation is unnecessary, the standard preparation containing six pounds of copper and four pounds of lime to twenty-two gallons of water. While the best effects from this mixture have been obtained when Knapsack pumps were used, it does not always pay to use such machines for work on a large scale. Where one has 30,000, or even 50,000, stocks, two Knapsack pumps can do the work.

For more than this, however, it is best to use horse power machines. We have recently devised two machines of this kind; the first a cart machine, holding twenty-five gallons, made to pump automatically, drawn by one horse and requiring two men and a boy to operate it. Four rows are sprayed at a time, so that it is not difficult to spray 100,000 or 150,000 pear seedlings a day with it. With a Knapsack pump 20,000 to 25,000 seedlings of this kind is a good day's work.

The second form of horse power machine is simply a barrel mounted upon wheels or runners and provided with a force pump which is worked by hand. With a horse, two men and a boy, four rows can also be sprayed at one time with this apparatus. The work cannot, however, be done as rapidly as with the automatic pump, although, owing to better control of the machine, it can be done more thoroughly. The cost of the automatic machine will range from forty dollars to fifty dollars, while the last described apparatus complete can be fitted up at home for fifteen dollars. This includes wheels or runners, pump, suction and discharge hose, four nozzles, and gearing for attaching the horse. A special feature of the machine we have devised is the pump, which is a modification of the one we use on our Knapsack sprayer. Most of the force pumps capable of supplying four nozzles are expensive, ranging in price from eight dollars to twenty dollars. The one under consideration can be made for two dollars and a half, and it is as durable and effective as any of the more expensive pumps. By attaching the pump to the automatic machine already mentioned the price of the same may be materially decreased. In fact, we are now perfecting an automatic apparatus that will spray four rows at a time, and which, we think, can be made for twenty-five dollars. The plan is to devise a machine so simple that the various parts may be obtained from almost any reliable implement dealer and put together at home. All the machines mentioned can be used for various purposes, such as spraying potato and tomato vines, grapes, nursery stock, and orchard trees.

Laying aside the question of machinery, let us turn again to the treatment of nursery stock and briefly summarize our present knowledge of this subject. We may say (1) that leaf blight of the pear, plum, cherry, and quince are best controlled by Bordeaux mixture, applied first when the leaves are one third grown, and thereafter at intervals of twelve or fifteen days, until six or seven sprayings in all have been made; (2) that the ammoniacal solution of copper carbonate, applied the same as the Bordeaux mixture, is most successful in combating powdery mildew of the apple. In the orchard, however, the ammoniacal solution has, for various reasons, been more satisfactory for pear leaf blight and scab than the Bordeaux mixture. It is also found that three or four early sprayings give as good results as six or seven made at intervals during the growing season. This statement may not hold good in the nursery, where, as yet, no experiments have been made to test the matter.

The first extended experiments in treating apple scab were made in 1889 by Professor Goff, of Wisconsin, and Professor Taft, of Michigan, under the direction of the Division of Vegetable Pathology. It was then demonstrated that scab could be cheaply prevented by at least two of the copper preparations, namely, ammoniacal solution and modified eau celeste. The cost of the treatment averaged about twenty-five cents per tree, while the increase of perfect fruit on the treated trees over the untreated ranged from twenty-five to seventy-five per cent. In 1890 we continued the experiment, endeavoring to obtain information on a number of other points, chief of which was the value of early as compared with late treatments, the number of treatments necessary to obtain the best results, and the comparative efficacy of three fungicides, two containing copper and one devoid of this chemical. An attempt was also made to cheapen the treatment without decreasing their efficacy. It was found that early treatments, particularly those made just as the flowers were opening, were better than late ones. Three early sprayings—one when the flowers were just opening, one when the fruit was the size of peas, and one two or three weeks later—proved as effective as five, six, or even seven sprayings made at intervals during the summer. The best fungicide was one originating with us last year, and sent out under the name of Mixture No. 5. It consists of equal parts of ammoniated copper sulphate and ammonium carbonate. It was used at the rate of from eight to twelve ounces to twenty-five gallons of water. The special advantages of the mixture are (1) cheapness, (2) ease of preparation and application, and (3) that it can be put up in dry form in small or large packages, making it easy and convenient to handle by the practical man in the field and the storekeeper who may wish to place it on the market. The chief objection to it is that it sometimes burns the foliage. While this drawback may in time be overcome, it is necessary that we know of it, in order that due care may be observed in using the solution. Work on the treatment of this disease is being carried on this year by us in the chief apple-growing sections of the country. As yet it is too early to speak definitely of results, but enough is known to warrant us in saying that many new points will be brought out. The conclusion of the matter is that, with even moderate care, apple scab can be largely prevented in the most badly affected regions at an expense ranging from ten to twenty cents per tree.

### FRUIT DISTRICTS GEOLOGICALLY AND CLIMATICALLY CONSIDERED.

Professor E. S. Goff read a carefully prepared paper on this subject. After giving many illustrations of the fact that certain regions, often of very limited area, are specially adapted to certain fruits, the author gave a brief general description of the irregular zones in which tropical and more hardy fruits are found at their best, and continued as follows:

It is a fact of importance to horticulture that, other things being equal, the further north a fruit district is located, the more profitable is the culture of the fruits to which it is adapted. Competition from the same latitude is not only restricted, but the cost of transported fruits is great. In more delicate fruits, as the raspberry, blackberry, and strawberry, the lateness of maturing in northern fruit districts shuts out southern competition. In the case of some other fruits, as the apple, the longer days of the more northern clime develop a brilliancy of color that is not found in regions further south. In Wisconsin, successful apple culture is limited to a comparatively few districts, and these are mostly of small extent, yet the profits realized from the few successful orchards surpass those from the finest orchards of western New York. These facts give an added interest to these northern fruit regions, and invite a study of the causes which serve to locate and circumscribe them.

Within a few years the eastern shores of Lake Michigan, particularly in the portion south of Grand Haven, have become famous for peaches. On the western shore of the same lake the peach rarely yields fruit, while a few miles further to the westward only the more hardy varieties of the apple can be successfully fruited. On the east shore of the lake, however, apples and even peaches are said to succeed as far north as Mackinaw, which is a degree north of the northern boundary of New York and Vermont. The causes for these differences of climate in a similar latitude, according to Professor Winchell, "must be attributed to the fact that the prevailing winds which bring frost or severe cold are westerly, reaching the easterly, or Michigan, shore only after having traversed nearly or quite one hundred miles of deep open water, to which, during the warm season, they will have surrendered a very considerable increment of heat, to be retained until it shall be wrestled for and reabsorbed by the colder gales of late autumn and winter, thus quenching their excess of cold by the transfer to them of a portion of the surplus heat of the warm season. . . . It is also a fact that a current sets northward along the easterly shore of Lake Michigan, doubtless occasioned by the increased influence of prevalent southwesterly winds upon the waters nearest that shore; and there is a reverse current along the westerly shore, thus causing a slow but constant transfer of the warm waters of the south toward the northern extremity of the lake, and vice versa, much in the same manner as the tepid waters of the Gulf of Mexico are transmitted by the Gulf Stream to soften the clime of northwestern Europe."

In like manner the southern and eastern shores of Lake Erie and the eastern shore of Lake Champlain present a somewhat softened climate as compared with localities more remote from water, making the former district well adapted to the culture of native grapes, and the latter to that of hardy apples. Even the smaller lakes of central New York, aided, doubtless, by the larger Lake Ontario to the north, are surrounded by fruit districts in which varieties of the grape and peach succeed that cannot be grown in northern Pennsylvania. Especially is this true of Keuka Lake, on the banks of which frosts hold off until the middle of October, and the Catawba grape ripens to perfection in the average season. The influence of physical features in modifying climate is strikingly shown in California. Here the combined influence of the great Pacific Ocean, with its Japan current washing the coast with waters tempered by a tropical sun, and the mountain barriers to the eastward, deflecting the northerly winds, actually cause the isothermal lines, which normally run east and west, to extend north and south. Indeed, in some cases, fruits ripen earlier in the northern than in the southern parts of the state.

At certain altitudes in the mountain districts of California and elsewhere occur belts of greater or less extent that are singularly free from spring and autumn frosts. These locations have been called "thermal belts," and are peculiarly adapted to fruit culture. Their altitude secures free circulation of air and immunity from violent summer heats, which make them less subject to many fungous diseases than the valleys beneath, while their almost complete freedom from frost gives them a prolonged growing season. In seasons when premature warm weather in spring is followed by severe frost, these thermal belts are sometimes conspicuous along the mountain sides from the lively green of their newly formed foliage, while both above and below the premature growth has been blasted by frost. The presence of these belts has been explained by the merging of the ascending current of warm air from the valleys beneath with the more rarefied atmosphere of the mountains. The warm currents ascend until they reach strata of equal rarefication with themselves, where they cease and merge themselves into the existing atmosphere.

It would seem that the great mountain regions of our western states and territories must abound in these thermal belts, and though comparatively few of them have as yet been developed for fruit culture, it is not impossible that the golden fruits and rich vintages of this vast mountain system may yet rival in value the output of their quartz mills and placers.

Certain fruits are especially susceptible to certain features of environment. The cranberry, it is said, cannot endure a soil that contains any considerable admixture of clay or lime. The European wine grape (*Vitis vinifera*) is very susceptible to extremes of atmospheric humidity; the fruit buds of the peach are very susceptible to the cold of winter. The area of successful culture for such fruits is greatly restricted as compared with what it might be but for these special weaknesses.

I may add, in conclusion, that the subject of plant adaptation should receive much more study than has yet been devoted to it. It would seem that a thorough study of plant environment in our distinctive fruit regions should enable us to establish a formula by which the adaptability of any given locality for any particular fruit might be determined without resorting to the costly method of experiment. What expense and disappointment might have been saved could it have been determined beforehand that the European grape could not succeed in the Eastern

United States! De Candolle, who has given much study to the geography of plants, was unable to explain their failure from any data that he could procure. Could he have had access to more complete meteorological facts, it is probable that he might have assigned the true cause. This, indeed, is the crying need. I have made some attempt at these studies, but have been disappointed at the meagerness of the available data. It is true that the reports of the signal service have very great value, but before the science of plant adaptation can be fully developed we must have series of observations reaching through years, not only of temperature, humidity, precipitation, cloudiness and wind, but of the intensity of sunshine, of soil temperatures and moistures, of the prevalence of fogs and dews; and we must have these observations not simply from one or two localities in a state, but from every locality that has a specially interesting economic flora. Those who are patiently making laborious observations at our signal service and experiment stations, and who often wonder if their patient labor will ever be appreciated, should take new courage. It is from data of this kind that a new science is to be developed that will prove of vast importance to a future generation.

FRUIT NOTES FROM CANADA.

Mr. L. Woolverton, of Grimsby, Ontario, reported some experience with different fruits in Canada, from which we make the following extracts:

Some standard apples which were once counted as most valuable from a commercial point of view are now condemned entirely by many of our leading growers. One of these is the Baldwin, which, for the past few years, has been almost barren. The Early Harvest and Fall Pippin, which were considered our principal summer and fall varieties, are now no longer of value, owing to the apple scab. Even the Northern Spy and Greening have of late been badly affected with this pest. We feel exceedingly grateful to the Department of Agriculture of the United States for the remedies which have been proposed for this and other fungi, and we are prepared to test them fully and report to you the results. During this last season I have sprayed faithfully with carbonate of copper, as recommended by your department, but there has been scarcely an appearance of the apple scab in our orchard, whether sprayed or unsprayed, and, consequently, we are unable, as yet, to judge of its effectiveness.

Concerning Russian apples, we are scarcely willing to condemn them wholesale, for we are finding among them some which we think will be suitable to the cold North; for instance, the Golden White, which has been tested in the province of Quebec, is exceedingly promising. Among native varieties, we think highly of the Wealthy, which has been tested faithfully in the County of Renfrew, and some of the members of our association looked upon it as the very best variety that has ever been tried in that section. Samples were sent to me last fall from there, and also some from farther south, but those grown at the north were far superior, both in size and color. Of Canadian seedling apples of promise the Princess Louise and the La Rue are worthy of notice. Renaud's Seedling is a winter apple which appears to be very promising. It is a chance seedling, found growing on the farm of Mrs. Renaud, at Grenville, forty five and a half degrees north latitude; should it prove equal to its promises in size, beauty, productiveness and hardiness, it will be a great boon to that section of country.

## MICRO-ORGANISMS AS INSECTICIDES.*

THE subject of bacteriology has occupied a very large share of public attention during the past fifteen or twenty years, and it is safe to say that the most important discoveries in medical science, especially in the treatment of diseases, have resulted during that time from this line of investigations. The paper indicates the many directions in which the study of these micro-organisms has proved invaluable to man by preventing disease, but is occupied chiefly with a phase of bacteriology which is the reverse of this, and which is concerned with the purposeful multiplication and dissemination of the contagious disease germs, with a view of destroying those animals and plants which we class as noxious because injurious to agriculture. The subject is treated under several different categories and refers, first, to the experiments which have already been made with yeast and yeast ferments; to experiments with entomophthora, experiments with Isaria, experiments with true bacterial diseases (schizomycoses), experiments with protozoan diseases, and concludes with a summary of the actual work done and a statement of the possibilities in the future. The paper refers to a series of experiments being carried on under the author's direction, by the Department of Agriculture, and the negative results from a practical standpoint, hitherto obtained. It also refers to the work of Prof. F. H. Snow, of Kansas, whose efforts to destroy the chinch bug attracted such wide attention through the newspapers the present year. The author condemns the sensational character that has been given to said work, and considers that some of the statements made and conclusions drawn are lacking in scientific foundation and will lead ultimately to disappointment.

"In this hasty glance," the paper concludes, "at what has been actually done from the experimental side in the use of contagious germs, as insecticides for the benefit of agriculture, imperfect as it has been, I hope I have said enough to indicate the vast importance of the subject. It is a subject at once alluring and promising, especially in connection with those gregarious insects which appear at times in such vast numbers and lay such heavy tribute on our most important crops. Unfortunately there is a great tendency, especially in the public mind, to take as proved what has not yet passed beyond the stage of possibility. In theory the idea of doing battle with insects injurious in field, garden, orchard and forest by means of these invisible germs is very tempting; but it has unfortunately been most dwelt upon by those who are essentially closet workers and had but a faint realization of the necessities of the case.

There are so many delicate questions involved, and so many obstacles in the way of carrying out any plan, however plausible in theory or true in principle. Our ability to contaminate healthy by diseased specimens is but a short step, and leaves many important questions as to rapid dissemination untouched. How complicated the whole subject is, and how carefully investigation should be made, may be gathered from the fact that, as in the case of the chinch bug, so in the case of most injurious insects, so far as studied, several different disease germs co-operate in the destruction. The subject, however, is one full of promise, and it is very unsafe to argue inductively, because most discoveries in this direction have been empirical. Though the theory of sound with its wave vibrations had been well elaborated by specialists, the phonograph, which is a practical exemplification of that theory, was stumbled upon almost by accident. So it has been in many great discoveries, and the advance in the practical application of these micro-organisms to the purpose which I have discussed will doubtless follow in the same line of empirical experiment. Nevertheless, success will more surely follow where experimentation is accompanied by full knowledge of the subject and by accurate scientific methods."

* Abstract of a paper read by C. V. Riley before Section F of the American Association for the Advancement of Science, Aug. 22, 1891.

## LIVE STOCK ON RANGES.

CENSUS Bulletin No. 117, prepared by Mr. Mortimer Whitehead, special agent of the Census Office, contains statistics of the range cattle industry in the United States, not including cattle on farms.

Since the census of 1880 great changes have taken place in the industry of range cattle. Large areas once used as ranges are now inclosed as farms, and the cattle are driven to new and distant feeding grounds. A large portion of Texas, Colorado, Oregon, Washington, and California, one-third of Kansas, and one-half of Nebraska, have been converted into farms during the last decade.

It is found that in June, 1890, there were upon the ranges 517,128 horses, 5,433 mules, 14,109 asses or burros, 6,828,182 cattle, 6,676,902 sheep, and 17,276 swine, with sales of horses in 1889 amounting to $1,418,205; of cattle, $17,913,712; of sheep, $2,669,663; and of swine, $27,132. The total number of men reported upon ranges in care of this stock is 15,390. The industry is found to be more generally prosperous at this time than for several years previous.




THE

Scientific American Supplement.

**PUBLISHED WEEKLY.**

**Terms of Subscription, $5 a year.**

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

**MUNN & CO., Publishers,**

**361 Broadway, New York, N. Y.**


TABLE OF CONTENTS.